



Allen-Bradley

1336 PLUS Adjustable Frequency AC Drive

with

SENSORLESS VECTOR

BP250 - BP450
CP350 - CP450

1336 PLUS
SENSORLESS VECTOR

Troubleshooting Guide

**Rockwell
Automation**

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Rockwell Automation publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Rockwell Automation office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

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Throughout this manual we use notes to make you aware of safety considerations:



ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is critical for successful application and understanding of the product.

Summary of Changes

The information below summarizes the changes since the last release.

Updated Information

August, 1999

575V AC information (CP350 – CP450) has been added to this manual. The following pages contain this new information:

- Table P.B has been added on page P-5
- Table P.F has been added on page P-7
- IMPORTANT statements have been added to Figure 5.3 on page 5-8.
- Ratings have been added to pages 6-1 and 6-3.
- Ratings have been added to pages 7-1 through 7-5

Information has been added to Overtemp Fault 08 in Table 2.A on page 2-6.

Information has been added to Test 3, Testing the Power Modules, beginning on page 4-9.

February, 2002

All illustrations have been changed to depict the new style Bus Fuse/Diode (F1) assembly with horizontal terminal block orientation.

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Preface

Manual Objective

The information in this manual is designed to help troubleshoot or repair an Rockwell Automation Bulletin 1336 PLUS Adjustable Frequency AC Drive with ratings BP250 – BP450.

Who Should Use This Manual

This manual is intended for qualified service personnel responsible for troubleshooting and repairing the 1336 PLUS Adjustable Frequency AC Drive. You should:

- Read this entire manual before performing maintenance or repairs to drives.
- Have previous experience with, and basic understanding of, electrical terminology, procedures, required troubleshooting equipment, equipment protection procedures and methods, and safety precautions.

This manual describes equipment, troubleshooting, and disassembly procedures. You begin with general illustrations and end with greater detail concerning replacement parts and part locations on the drives. Later chapters may refer you back to earlier chapters for information on basic equipment and steps necessary to perform detailed diagnostics and part replacement.

Safety Precautions



ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove and lock out power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/–DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Potentially fatal voltages may result from improper usage of oscilloscope and other test equipment. The oscilloscope chassis may be at a potentially fatal voltage if not properly grounded. If an oscilloscope is used to measure high voltage waveforms, use only a dual channel oscilloscope in the differential mode with X 100 probes. It is recommended that the oscilloscope be used in the A minus B Quasi-differential mode with the oscilloscope chassis correctly grounded to an earth ground.



ATTENTION: Only personnel familiar with the 1336 PLUS Adjustable Frequency AC Drive and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

Electrostatic Discharge Precautions



ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Rockwell Automation Publication 8000-4.5.2, Guarding Against Electrostatic Damage, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

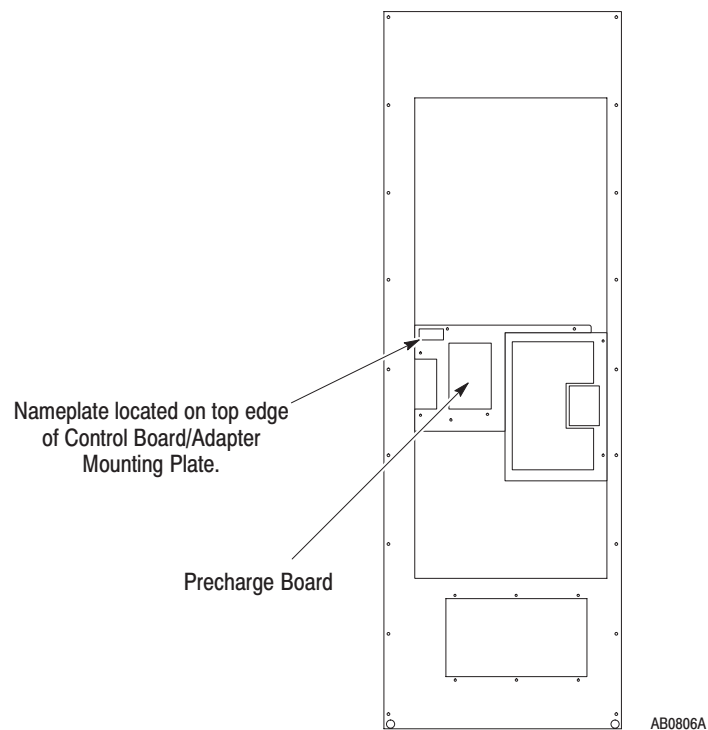
- Wear a wrist-type grounding strap that is grounded to the drive chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

1336 PLUS Product Identification

Drive Nameplate Location

The drive nameplate is located on the face of the Main Control Board Mounting Plate. The drive nameplate contains the drive's catalog number and other important drive information. Reference the catalog number when ordering replacement parts.

Figure P.1 Drive Nameplate Location



Software Compatibility

Three-Phase Drive Rating ¹		
380 – 480V	Compatible with Version	Frame Reference
187 – 336 kW 250 – 450 HP	4.01 & Up	F

¹ kW and HP are constant torque (CT) ratings.

Drive and Option Identification

The following is an explanation of the catalog numbering system for 1336 PLUS Adjustable Frequency AC Drives and options. The catalog number is coded to identify the drive power rating and can be found on the drive shipping carton and nameplate.

1336 PLUS Drive Catalog Numbers

Table P.A

1336S	– AQF15-AA	– EN	– L6	– HA1	– GM1
BULLETIN NO.	RATING-ENCLOSURE (MUST BE SPECIFIED)	LANGUAGE MODULE ^[3] (MUST BE SPECIFIED)	CONTROL INTERFACE ^[3] (OPTIONAL)	HUMAN INTERFACE ^[3] (OPTIONAL)	COMMUNICATION CARD ^[3] (OPTIONAL)

380 – 480V AC Input, Constant or Variable Torque Drive

Drive Rating ^[1]					Enclosures			
					Open IP00 No Enclosure	NEMA Type 1 IP20 General Purpose	NEMA Type 4 IP65 Resist Water, Dust	NEMA Type 12 IP54 Industrial Use
Frame Designation	Constant Torque		Variable Torque ^[2]		Code	Code	Code	Code
	Output Amps	Nominal HP	Output Amps	Nominal HP				
F	325.0	250	360.0	300	BP250-AN	BP250-AA	^[4]	—
	360.0	300	425.0	350	BP300-AN	BP300-AA	^[4]	—
	425.0	350	475.0	400	BP350-AN	BP350-AA	^[4]	—
	475.0	400	532.0	450	BP400-AN	BP400-AA	^[4]	—
	532.0	450	532.0	450	BP450-AN	BP450-AA	^[4]	—

^[1] Drive rating is based on a carrier frequency of 4kHz maximum, an altitude of 1,000 meters or less, and a maximum ambient temperature of 40°C.

^[2] VT Ratings do not apply to 380V Input.

^[3] Refer to the Language Module and Options tables following these Catalog Number tables.

^[4] Not available in this rating.

1336 PLUS Drive Catalog Numbers

Table P.B

1336S	– AQF15-AA	– EN	– L6	– HA1	– GM1
BULLETIN NO.	RATING-ENCLOSURE (MUST BE SPECIFIED)	LANGUAGE MODULE ^[3] (MUST BE SPECIFIED)	CONTROL INTERFACE ^[3] (OPTIONAL)	HUMAN INTERFACE ^[3] (OPTIONAL)	COMMUNICATION CARD ^[3] (OPTIONAL)

575V AC Input, Constant or Variable Torque Drive

Drive Rating ^[1]					Enclosures			
					Open IP00 No Enclosure	NEMA Type 1 IP20 General Purpose	NEMA Type 4 IP65 Resist Water, Dust	NEMA Type 12 IP54 Industrial Use
Frame Designation	Constant Torque		Variable Torque ^[2]		Code	Code	Code	Code
	Output Amps	Nominal HP	Output Amps	Nominal HP				
F	350.0	350	350.0	350	CP350	—	^[4]	—
	400.0	400	400.0	400	CP400	—	^[4]	—
	450.0	450	450.0	450	CP450	—	^[4]	—

^[1] Drive rating is based on a carrier frequency of 4kHz maximum, an altitude of 1,000 meters or less, and a maximum ambient temperature of 40°C.

^[2] VT Ratings do not apply to 380V Input.

^[3] Refer to the Language Module and Options tables following these Catalog Number tables.

^[4] Not available in this rating.

Table P.C

Language Modules	
Description	Option Code
English/English	EN4
English/French	FR4
English/German	DE4
English/Italian	IT4
English/Japanese	JP4
English/Spanish	ES4

Table P.D

Options			
Code	Description	Code	Description
Human Interface Module, NEMA Type 1 (IP 20)		Communication Options	
HAB	Blank – No Functionality	GM1	Single Point Remote I/O
HAP	Programmer Only	GM2	RS-232/422/485, DF1 & DH485
HA1	Programmer/Controller w/Analog Pot	GM3	DeviceNet
HA2	Programmer/Controller w/Digital Pot		
Human Interface Module, NEMA Type 4 (IP 65)		Control Interface Options	
HJP	Programmer Only	L4	TTL Contact
HF1	Programmer, LCD/Analog Pot	L4E	TTL Contact & Encoder Feedback
HJ2	Programmer/Controller w/Digital Pot	L5	24V AC/DC
		L5E	24V AC/DC & Encoder Feedback
Human Interface Module, NEMA Type 12 (IP 54)		L6	115V AC
		L6E	115V AC & Encoder Feedback
HJP	Programmer Only		
HJ2	Programmer/Controller w/Digital Pot		

Table P.E 380 – 480V Drives

Catalog Number	Maximum Output Amp Rating ^{1 5}		Derate Curve ^{1 2}	Heat Dissipation Drive Watts ^{1 2 3}	Heat Sink Watts ¹	Total Watts ¹
	CT	VT				
BP250	325.0	360.0	⁴	⁴	⁴	⁴
BP300	360.0	425.0	⁴	⁴	⁴	⁴
BP350	425.0	475.0	⁴	⁴	⁴	⁴
BP400	475.0	532.0	⁴	⁴	⁴	⁴
BP450	532.0	532.0	⁴	⁴	⁴	⁴

¹ Rating is at 4kHz. If carrier frequencies above 4kHz are selected, drive rating must be derated.

² Drive Ambient Temperature Rating is 40°C. If ambient exceeds 40°C, the drive must be derated.

³ Drive Rating is based on altitudes of 1,000m (3,000 ft) or less. If installed at higher altitude, drive must be derated.

⁴ Refer to the 1336 PLUS User Manual, Appendix A.

⁵ CT = Constant Torque
VT = Variable Torque

Table P.F 575V Drives

Catalog Number	Maximum Output Amp Rating ¹ ⁵		Derate Curve ¹ ²	Heat Dissipation Drive Watts ¹ ² ³	Heat Sink Watts ¹	Total Watts ¹
	CT	VT				
CP350	350.0	350.0	⁴	⁴	⁴	⁴
CP400	400.0	400.0	⁴	⁴	⁴	⁴
CP450	450.0	450.0	⁴	⁴	⁴	⁴

¹ Rating is at 4kHz. If carrier frequencies above 4kHz are selected, drive rating must be derated.

² Drive Ambient Temperature Rating is 40°C. If ambient exceeds 40°C, the drive must be derated.

³ Drive Rating is based on altitudes of 1,000m (3,000 ft) or less. If installed at higher altitude, drive must be derated.

⁴ Refer to the 1336 PLUS User Manual, Appendix A.

⁵ CT = Constant Torque
VT = Variable Torque

Drive Rating Qualifications

Several factors can affect drive rating. If more than one factor exists, consult Rockwell Automation.

Enclosure Type

The first character, A, indicates the Enclosure Code.

The second character indicates the type of enclosure shipped from the factory:

Table P.G Enclosure Type Code Description

Enclosure Type Code	Description
N	Open style (IP 00)
A	NEMA Type 1 (IP 20)
F	NEMA Type 4 (IP 65)
J	NEMA Type 12 (IP 54)

Conventions

To help differentiate parameter names and display text from other text in this manual, the following conventions will be used:

- Parameter Names will appear in [brackets].
- Display Text will appear in “quotes”.

The following is a list of conventions used throughout this manual, and definitions of the conventions. For a list of terminology and definitions, refer to the Glossary in the back of this manual.

Auxiliary Input

The Auxiliary Input is a terminal connection on the Control Interface Board. This connection provides an external input for use as an Auxiliary Interlock. Unless this interlock is closed, the drive will be faulted with an Auxiliary Fault.

Auxiliary Interlock

The Auxiliary Interlock is a user-supplied circuit consisting of reset, overload, or other interlocking circuitry. The Interlock is wired to the drive Auxiliary input.

Bit

A bit is a single character or status point used in programmable logic. Eight bits form a BYTE, 16 bits form a word. Drive parameters are actually eight bits or 16 bit words.

Check

To check means to examine either the physical condition of something or the setting of some control, such as a Parameter. Checking a drive board or component may also require measurements and tests.

Connector

A connector connects one drive board to another. Connectors come in two designs, male and female. Male connectors are stationary and contain pins, which are sometimes joined by jumpers. Female connectors are at the ends of wires or ribbon cables and plug into male connectors.

Default

When a drive function defaults, it automatically changes to a pre-programmed setting.

Enable Input

The Enable Input is a terminal connection on the Control Interface Board. This connection provides an external input to enable or disable the Drive Output section. It must be true to permit the drive to operate.

False

False refers to a logical false state. For instance, a Control Interface signal on TB3 is false when the input contact is open or the appropriate voltage is not applied to the Control Interface Board.

Jumper

A jumper completes a circuit between two pins within a male connector on a drive board. In the absence of certain optional equipment using female connectors, jumpers are applied to certain pins within a male connector to complete specific and necessary circuits.

Control Interface Board

A Control Interface Board plugs into connectors J7 and J9, located on the lower portion of the Main Control Board. This board is identified as L4/4E, L5/5E or L6/6E and provides optional control wiring configurations for a drive.

Parameter

Parameters are programmable drive functions that define various operating functions or status displays of a drive. Refer to Bulletin 1336 PLUS Adjustable Frequency AC Drive User Manual for Parameter details.

Press

Press a button on the Human Interface Module to change Parameter settings and drive functions.

True

True refers to a logical true state. For instance, a Control Interface signal on TB3 is true when: L4/L4E contact input is closed, L5/L5E input terminal registers 24V, or L6/L6E input terminal registers 115V AC.

Related Publications

The following lists other Rockwell Automation publications that apply to the 1336 PLUS Adjustable Frequency AC Drives with ratings BP250 – BP450:

- Product Data (1336 PLUS-1.0)
- User Manual (1336 PLUS-5.0)
- Option Manuals/Instructions
- Renewal Parts List (1336-6.5)

Control Logic Wiring and Adapters

Chapter Objectives

This chapter introduces you to terminal block locations and wiring, and adapter locations and functions.

Chapter Overview

This chapter illustrates and describes:

- Control Logic Interface Options L4, L5, and L6, including Terminal Block TB3
- TB3 input mode selections and functions
- TB3 terminal designations

Important: All printed circuit boards, except the Main Control Board assembly, are referenced to negative ground (–bus).

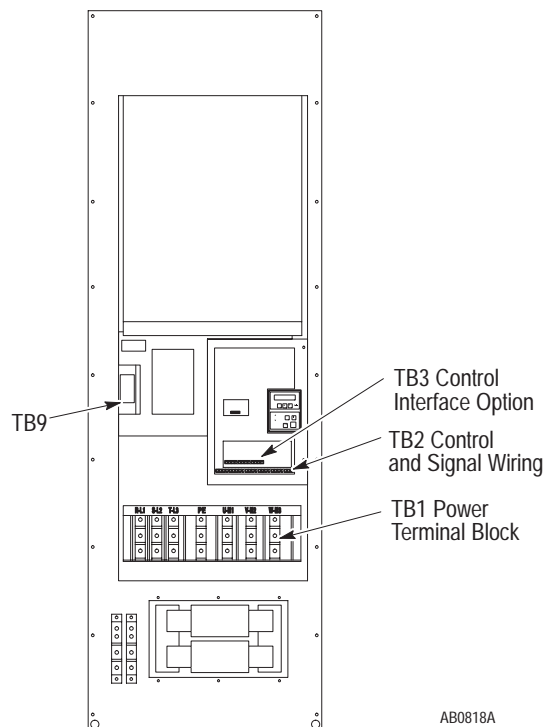


ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/–DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Rockwell Automation Publication 8000–4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Figure 1.1 Terminal Block Locations



ATTENTION: The National Electrical Code (NEC) and local codes outline provisions for safely installing electrical equipment. Installation must comply with specifications regarding wire types, conductor sizes, branch circuit protection and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

Control Interface Option

The Control Interface Option provides a means of interfacing various signals and commands to the 1336 PLUS by using contact closures.

Six different versions of the option are available:

- L4 Contact Closure Interface¹
- L4E Contact Closure Interface with Encoder Feedback Inputs¹
- L5 +24V AC/DC Interface
- L5E +24V AC/DC Interface with Encoder Feedback Inputs
- L6 115V AC Interface
- L6E 115V AC Interface with Encoder Feedback Inputs

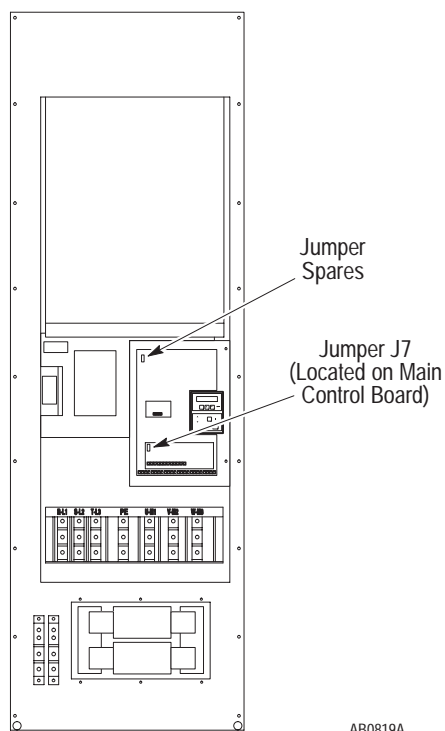
¹ Uses internal +5V DC supply.

The user inputs are connected to the option board through TB3. The L4, L5 and L6 options each have nine control inputs. The function of each input must be selected through programming as explained later in this section. The L4E, L5E and L6E options are similar to L4, L5 and L6 with the addition of encoder feedback inputs.

Control Interface Board Jumpers

Important: If the Control Interface Board is being installed, Main Control Board jumpers at pins 3 & 4 and 17 & 18 of J4 (J7 on 7.5 – 30 HP drives) must be removed. If removed, these jumpers can be stored on the “spares” location on the Main Control Board. If this board is removed, these jumpers must be reinstalled and the [Input Mode] parameter must be programmed to “1”.

Figure 1.2 Jumper Locations



Available Inputs

A variety of combinations made up of the following inputs are available.

Start	Enable
Stop/Clear Fault	Auxiliary
Reverse	2 Stop Mode Selects
Digital Potentiometer (MOP)	Run Forward
2 Accel/Decel Rates	Run Reverse
3 Speed Selects	Local Control

The available combinations are shown in Figure 1.4. Programming the [Input Mode] parameter to one of the Input Mode numbers listed selects that combination of input functions.

Important: The [Input Mode] parameter can be changed at any time, however, programming changes will not take affect until power has been cycled to the drive. When changing an input mode, it is important to note that the corresponding inputs to TB3 may also change.

The programming options of the Control Interface Option allow the user to select an input combination to meet the needs of a specific installation. Appropriate selection of a combination may be done by using Table 1.A. First determine the type of start/stop/direction control desired. Then select the remaining control functions available. After selecting a group of Input Modes use Figure 1.4 for specific mode selection. Record the selected mode number below.

Selected Mode Number: _____

Local Programming

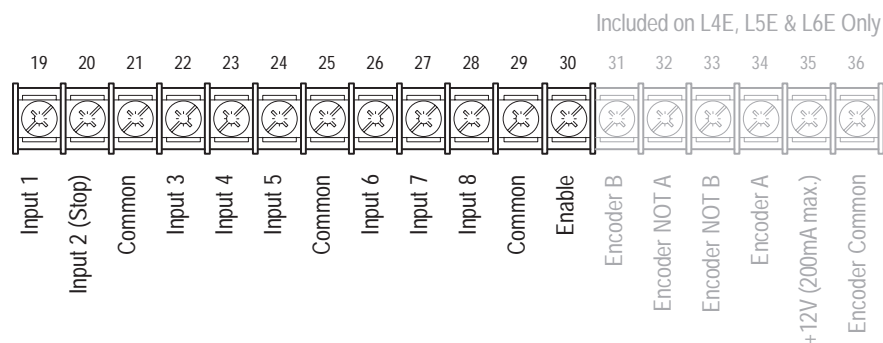
For local programming and control information, refer to the 1336 PLUS User Manual.

Table 1.A Input Mode Selection

Start/Stop Type	Direction Control	Communication Compatibility	Mode(s) to Use
Stop & Enable Only	None	Control must be provided by HIM or Communication Option.	1
Momentary Pushbutton (3 Wire)	Maintained Switch (Open-Forward, Closed-Reverse)	Start/Stop – works in parallel with HIM and Communication Options. Direction Control will not work in parallel with HIM or Communication Options. User must select direction control from either HIM and Communication Options or TB3 input.	2 – 6, 17, 18 & 22
Momentary Pushbutton (3 Wire)	Momentary Pushbuttons (Forward and Reverse)	Start/Stop – works in parallel with HIM and Communication Options. Direction – works in parallel with HIM or Communication Options.	7 – 11, 19 & 23
Maintained switches for combined run and direction control (2 wire, Run Forward, Run Reverse)		Start/Stop – not compatible with HIM or Communication Options. Direction – not compatible with HIM or Communication Options.	12 – 16, 20, 21 & 24

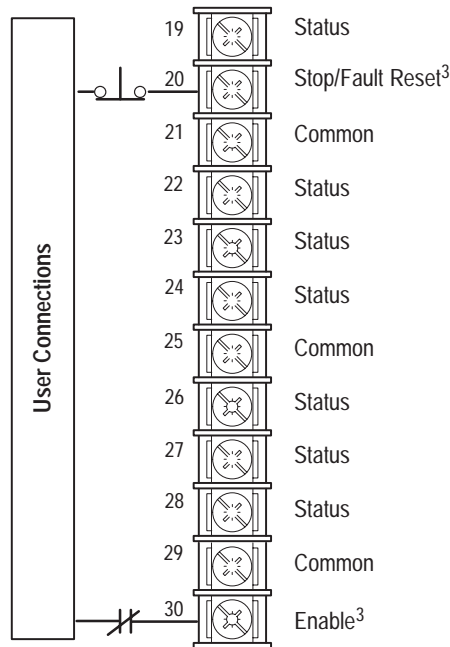
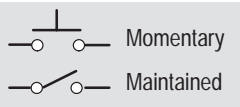
Figure 1.3 provides the terminal designations for TB3. The maximum and minimum wire sizes accepted by TB3 are 2.1 and 0.30 mm² (14 and 22 AWG). Recommended torque for all terminals is 0.9 – 1.13 N-m (8 – 10 lb-in.). Use Copper wire only.

Figure 1.3 TB3 Terminal Designations



AB0293B

Figure 1.4
Input Mode Selection and Typical TB3 Connections



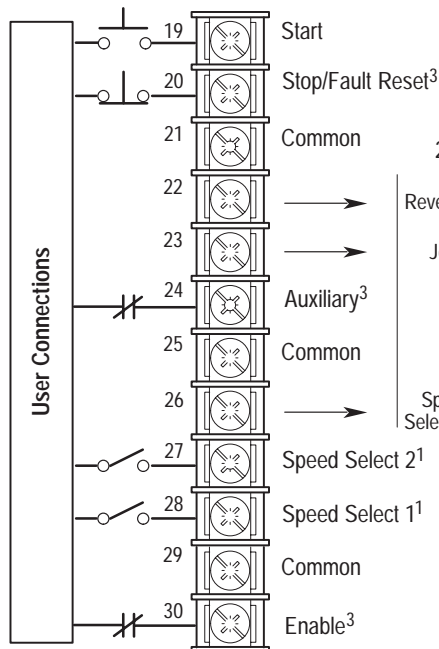
[Input Mode] 1
Factory Default

Note: If this mode is selected, the status of all inputs can be read at the [Input Status] parameter. However, only "Stop/Fault Reset" and "Enable" will have control function.

[Input Mode] 2 - 6, 17, 18, 22
Three-Wire Control with Single-Source Reversing

ATTENTION: The JOG function will not operate properly unless a SCANport option is connected to the drive. To assure proper JOG function, install at least one of the following:

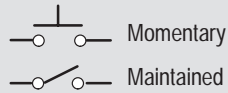
- 1201-HAP, 1201-HA1, 1201-HA2, 1336-GM1. Applies to 1305 with firmware FRN 2.01 or earlier and 1336 PLUS with Language Module 1336S-EN firmware FRN 1.05 or earlier.



	Mode							
	2	3	4	5	6	17	18	22
22	Reverse⁴	Reverse⁴	Reverse⁴	Reverse⁴	Reverse⁴	Reverse⁴	Integrator Reset⁶	Integrator Reset⁶
23	Jog⁷	Stop Type	2nd Accel	Digital Pot Up	Jog⁷	Jog⁷	Jog⁷	PI Output
26	Speed Select 3¹	Speed Select 3¹	2nd Decel	Digital Pot Dn	Local Control²	2nd Decel	Speed Select 3¹	Local Control²

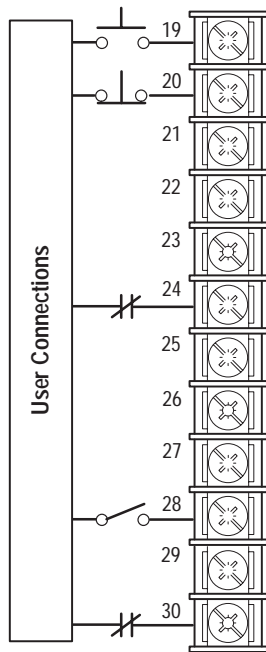
- 1 See Table 1.B.
- 2 Drive must be stopped to take Local Control. Control by all other adapters is disabled (except Stop).
- 3 These inputs must be present before drive will start.
- 4 Bit 0 of [Direction Mask] must = 1 to allow TB3 direction change.
- 5 Firmware version 3.01 and Up, Only.
- 6 Inverted function – voltage resets integrator to zero.
- 7 See ATTENTION statement on this page.
- 8 Firmware version 4.01 and Up, Only.

AB0290B



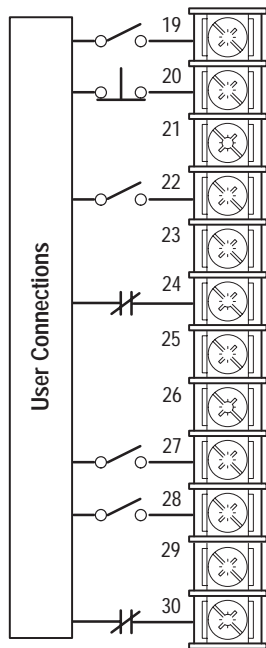
ATTENTION: The JOG function will not operate properly unless a SCANport option is connected to the drive. To assure proper JOG function, install at least one of the following:

1201-HAP, 1201-HA1, 1201-HA2, 1336-GM1. Applies to 1305 with firmware FRN 2.01 or earlier and 1336 PLUS with Language Module 1336S-EN firmware FRN 1.05 or earlier.



[Input Mode] 7 - 11, 19, 23
Three-Wire Control with Multi-Source Reversing

Mode							
7	8	9	10	11	19 ⁵	23 ⁸	
Reverse ⁴	Reverse ⁴	Digital Pot Up	Reverse ⁴	1st Accel	Reverse ⁴	Reverse ⁴	
Forward	Forward	Digital Pot Dn	Forward	2nd Accel	Forward ⁴	Forward ⁴	
Jog	Speed Select 3 ¹	Speed Select 3 ¹	Digital Pot Up	1st Decel	Integrator Reset ⁶	Integrator Reset ⁶	
Speed Select 2 ¹	Speed Select 2 ¹	Speed Select 2 ¹	Digital Pot Dn	2nd Decel	Speed Select 3 ¹	PI Output	



[Input Mode] 12 - 16, 20, 21, 24
Two-Wire Control, Single-Source Control

Mode							
12	13	14	15	16	20 ⁵	21 ⁸	24 ⁸
Local Control ²	Stop Type	2nd Accel	Digital Pot Up	Local Control ²	Local Control ²	Jog ⁷	PI Output
Speed Select 3 ¹	Speed Select 3 ¹	2nd Decel	Digital Pot Dn	Stop Type	Integrator Reset ⁶	Speed Select 3 ¹	Integrator Reset ⁶

1 See Table 1.B.

2 Drive must be stopped to take Local Control.

Control by all other adapters is disabled (except Stop).

3 These inputs must be present before drive will start.

4 Bit 0 of [Direction Mask] must = 1 to allow TB3 direction change.

5 Firmware version 3.01 and Up, Only.

6 Inverted function – voltage resets integrator to zero.

7 See ATTENTION statement on this page.

8 Firmware version 4.01 and Up, Only.

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Table 1.B defines the input state of the Speed Select inputs for a desired frequency source.

Table 1.B Speed Select Input State vs. Frequency Source

Speed Select 3	Speed Select 2	Speed Select 1	Frequency Source
O	O	O	[Freq Select 1]
O	O	X	[Freq Select 2]
O	X	O	[Preset Freq 2]
O	X	X	[Preset Freq 3]
X	O	O	[Preset Freq 4]
X	O	X	[Preset Freq 5]
X	X	O	[Preset Freq 6]
X	X	X	[Preset Freq 7]

O = Open

X = Closed

Human Interface Module (HIM)

Description

When the drive mounted HIM is supplied, it will be connected as Adapter 1 (refer to Figure 1.6) and will be visible from the front of the drive. The HIM can be divided into two sections; Display Panel and Control Panel. The Display Panel provides a means of programming the drive and viewing the various operating parameters. The Control Panel allows different drive functions to be controlled. Refer to the 1336 PLUS User Manual for HIM operation.

Important: The operation of HIM functions depends upon drive parameter settings. Default parameter values allow full HIM functionality.

Figure 1.5 Adapter Locations

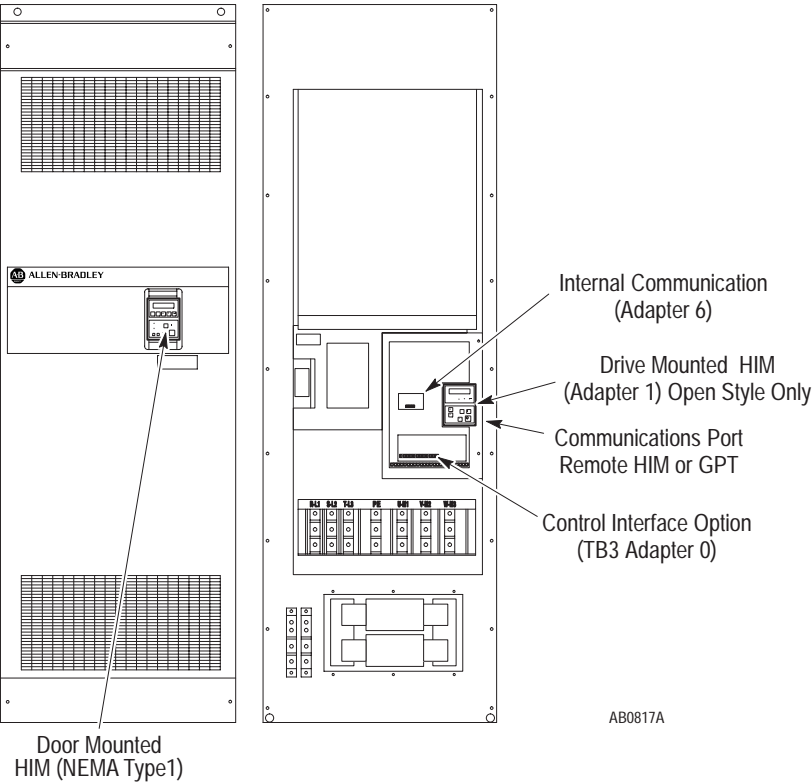
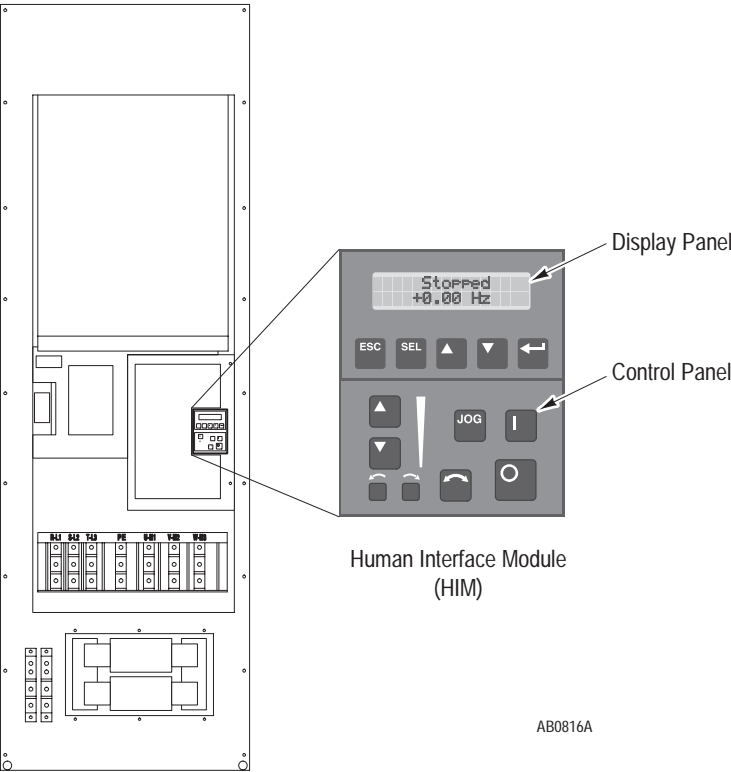


Figure 1.6 Human Interface Module



HIM Module Removal



ATTENTION: Some voltages present behind the drive front cover are at incoming line potential. To avoid an electric shock hazard, use extreme caution when removing/replacing the HIM.

For handheld operation, the module can be removed and located up to 10 meters (33 feet) from the drive.

Important: Power must be removed from the drive or the appropriate bit of the [Logic Mask] parameter must be set to “0” to allow removal of the HIM module without causing a Communication Fault. Setting the appropriate bit of the [Logic Mask] parameter to “0” allows HIM removal while power is applied to the drive. Note that this also disables all HIM control functions except Stop.

To remove the module:

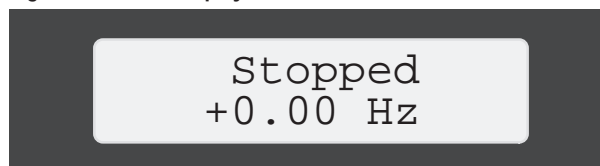
1. Assure that power has been removed or the appropriate [Logic Mask] bit has been set to “0”.
2. Take the drive front cover off and slide the module down and out of its cradle. Otherwise, unplug the cable between the HIM and the Communications Port (Adaptor 2, 3, 4, or 5).
3. Reverse the above steps to replace the module. Apply power or reset the appropriate bit of the [Logic Mask] parameter to “1” to enable HIM control.

HIM Operation

When power is first applied to the drive, the HIM will cycle through a series of displays. These displays will show drive ID and communication status. Upon completion, the Status Display (refer to Figure 1.7) will be shown. This display shows the current status of the drive (i.e., Stopped, Running, etc.) or any faults that may be present (Not Enabled, etc.).

Refer to the 1336 PLUS User Manual for HIM operation.

Figure 1.7 Status Display



Troubleshooting and Error Codes

Chapter Objectives

This chapter helps you trace faults to field-replaceable components.

Troubleshooting Overview

To troubleshoot a 1336 PLUS Adjustable Frequency AC Drive, you need a Range DVM, DMM, or VOM with a range capacity of at least 1000 V.

Important: All printed circuit boards are referenced to “common” per the schematic diagrams.



ATTENTION: Power circuits are optically isolated from control driver circuits. Power circuit components are “floating” with respect to “ground”. Use only approved methods of isolating test equipment when making measurements in power circuits.



ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/–DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Potentially fatal voltages may result from improper usage of oscilloscope and other test equipment. The oscilloscope chassis may be at a potentially fatal voltage if not properly grounded. We do not recommend use of an oscilloscope to directly measure high voltages. Use an isolated measuring device with a high voltage probe. Contact Rockwell Automation for recommendations.



ATTENTION: To guard against equipment damage when troubleshooting the drive, always check the following before issuing a Start command:

- Set the Speed Reference to minimum.
 - Select the proper motor-rotation direction.
 - Disconnect the motor from its mechanical load.
-



ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Rockwell Automation Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic Discharge Precautions

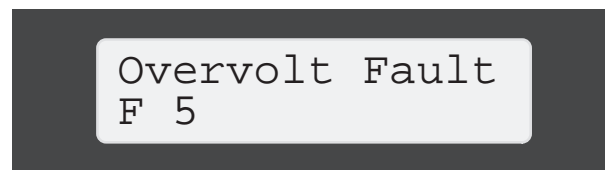
Electrostatic Discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

Fault Descriptions

Fault Display

The LCD display is used to indicate a fault by showing a brief text statement relating to the fault (see figure below). The fault will be displayed until a drive reset is initiated. Refer to Table 2.A for a listing and description of the various faults. Table 2.B provides a listing of faults by number.



Important: Before clearing a fault, refer to the Fault Descriptions table and Diagnostic Procedures by Symptom flowcharts in this chapter to isolate and correct faults.

To help differentiate parameter names and display text from other text in this manual, the following conventions will be used:

- Parameter Names will appear in [brackets]
- Display Text will appear in “quotes”

Contact Description

During normal operating conditions (no faults present, drive running) the CR3 fault contacts at TB2-13 & 14 are open, and the contacts at TB2-14 & 15 are closed. When a fault occurs, the state of these contacts changes.

Table 2.A 1336 PLUS Fault Descriptions

Name & Fault #	Description	Action
Adptr Freq Err 65	The SCANport adapter that was the selected frequency reference sent a frequency greater than 32767 to the drive.	Correct the problem that is causing the SCANport adapter to send the illegal frequency reference to the drive.
Auxiliary Fault 02	The auxiliary input interlock is open.	If Control Interface option is installed, check connections at TB3-24. If option is not installed, set [Input Mode] to "1".
BGND 10ms Over 51	Microprocessor loop fault. Occurs if the 10ms background task hasn't been run in 15 ms.	Replace Main Control Board or complete drive as required.
Blwn Fuse Flt 58	If the difference between the commanded voltage and the measured voltage is greater than 1/8 of rated voltage for 0.5 seconds, then a fault will be issued indicating that the bus fuse in 30 kW (40 HP) and up drives has blown.	Locate cause, replace fuse.
Diag C Lim Flt 36	The drive output current has exceeded the hardware current limit and the [Cur Lim Trip En] parameter was enabled.	Check programming of [Cur Lim Trip En] parameter. Check for excess load, improper DC boost setting, DC brake volts set too high or other causes of excess current.
Drive Fault Reset 22	Power-up has been attempted with an Open Stop contact or Closed Start contact.	Check/verify wiring and contact operation.
Drive → HIM	Error 1 – The checksum read from the EEPROM does not match the checksum calculated from the EEPROM data.	Repeat operation. Replace HIM.
EE Init Read 53	1. Gate Driver Board replacement (requires re-initialization). 2. Trouble reading EEPROM during initialization.	1. Reset to factory defaults & reset fault. 2. Check all connections to the Power/Driver Board. Replace the board or complete drive as needed.
EE Init Value 54	Stored parameter value is out of range on initialization.	Check all connections to the Power/Driver Board. Replace the board or complete drive as needed.
EEprom Checksum 66	The checksum read from the EEPROM does not match the checksum calculated from the EEPROM data.	Check all wire and cable connections to the Power Driver Board. Replace Power Driver Board or complete drive as required.
EEprom Fault 32	EEPROM is being programmed and will not write a new value.	Check all wire and cable connections to the Main Control Board. Replace Main Control Board or complete drive as required.
FGND 10ms Over 52	Microprocessor loop fault. Occurs if a 10ms interrupt is pending before the current interrupt is complete.	Replace Main Control Board or complete drive as required.
Ground Fault 13	A current path to earth ground in excess of 100A has been detected at one or more of the drive output terminals. NOTE: If ground current exceeds 220% of drive rated current, "Overcurrent Flt" may occur instead of Ground Fault.	Check the motor and external wiring to the drive output terminals for a grounded condition.
Ground Warning 57	A current path to earth ground in excess of 2A has been detected at one or more of the drive output terminals. See [Ground Warning].	Check the motor and external wiring to the drive output terminals for a grounded condition.

Table 2.A (continued)
1336 PLUS Fault Descriptions

Name & Fault #	Description	Action
Hertz Err Fault 29	This fault indicates that there is not a valid operating frequency. It can be caused by any of the following: 1. [Maximum Freq] is less than [Minimum Freq]. 2. Skip frequencies and skip bandwidth; eliminate all operating frequencies. 3. 4–20mA input signal speed reference has been lost and [4–20mA Loss Sel] is set for “Stop-Fault.”	1. Check [Minimum Freq] and [Maximum Freq] parameters. 2. Check [Skip Freq 1], [Skip Freq 2], [Skip Freq 3] and [Skip Freq Band] parameters. 3. Check for broken wires, loose connections or transducer loss at 4–20mA input, TB2.
Hertz Sel Fault 30	A frequency select parameter has been programmed with an out of range value.	Reprogram [Freq Select 1] and/or [Freq Select 2] with a correct value. If problem persists, replace Main Control Board or complete drive.
HIM → Drive	Error 1 – The checksum read from the EEPROM does not match the checksum calculated from the EEPROM data. Error 2 – Number of parameters in saved profile does not equal master. Error 3 – Download was attempted to a different type drive (i.e. 1336 → 1305). Error 4 – Saved data not correct for new drive. Error 5 – Drive is running while attempting download.	Retry download. Replace HIM. Retry download. Replace HIM. Download can only take place with same type drive. Capabilities of drive different than master drive. Reprogram param. Stop drive, then perform download.
Loop Overrn Flt 23	An overrun of the 2.5ms control loop has occurred.	Check all connections to the Power/Driver Board. Replace the board or complete drive as required.
Max Retries Fault 33	Drive unsuccessfully attempted to reset a fault and resume running for the programmed number of [Reset/Run Tries].	Check fault buffer for fault code requiring reset. Correct the cause of the fault and manually clear by pressing the local Stop key or cycling the TB3 Stop input.
Motor Mode Flt 24	A fault has been detected originating from the Control Board.	Check all connections to the Control Board. Replace the board, Language Module, or complete drive as required.
Motor Stall Fault 06	Current remained over 150% of [Rated Amps] for more than 4 seconds.	If the motor is drawing excessive current (over 150%), the motor load is excessive and will not allow the drive to accelerate to set speed. A longer accel time or a reduced load may be required.
Neg Slope Fault 35	Drive software detected a portion of the volts/hertz curve with a negative slope.	Check drive programming: 1. [Maximum Voltage] parameter must be greater than [Base Voltage]. 2. [Maximum Freq] parameter must be greater than [Base Frequency]. 3. [Base Voltage] parameter must be greater than [Start Boost]. 4. If the [DC Boost Select] parameter is set to “Full Custom”, [Base Voltage] must be greater than [Break Voltage] and [Break Voltage] must be greater than [Start Boost].

Table 2.A (continued)
1336 PLUS Fault Descriptions

Name & Fault #	Description	Action
Open Pot Fault 09	An external pot is connected and the common side of the pot is open. The drive generates this fault when the voltage between TB2-2 and TB2-3 exceeds 3.9V DC	Check the external potentiometer circuit at TB2, terminals 1, 2 and 3 for an open circuit.
Op Error Fault 11	A SCANport device requests a Read or Write of a data type not supported. This will also occur if: 1. [Motor Type] is set to "Sync PM" and [Stop Mode Used] is set to "DC Brake", or 2. [Motor Type] is set to "Sync Reluc" or "Sync PM" and [Speed Control] is set to "Slip Comp".	Check programming.
Overcurrent Flt 12	Overcurrent is detected in instantaneous overcurrent trip circuit.	Check for a short circuit at the drive output or excessive load conditions at the motor.
Overload Fault 07	Internal electronic overload trip.	An excessive motor load exists. It must be reduced such that drive output current does not exceed the current set by the [Overload Amps] parameter.
Overtemp Fault 08	Heat sink temperature exceeds a predefined value of 90 °C (195 °F).	Check for blocked or dirty heat sink fins. Check that the ambient temperature has not exceeded 40 °C (104 °F). Check fan. Check thermistor. Thermistor should register 100kΩ at room temperature.
Overvolt Fault 05	DC bus voltage exceeded maximum value.	Monitor the AC line for high line voltage or transient conditions. Bus overvoltage can also be caused by motor regeneration. Extend the decel time or install dynamic brake option.
Phase U Fault 38	A phase to ground fault has been detected between the drive and motor in this phase.	Check the wiring between the drive and motor. Check motor for grounded phase.
Phase V Fault 39	A phase to ground fault has been detected between the drive and motor in this phase.	Check the wiring between the drive and motor. Check motor for grounded phase.
Phase W Fault 40	A phase to ground fault has been detected between the drive and motor in this phase.	Check the wiring between the drive and motor. Check motor for grounded phase.
P Jump Err Flt 37	Reserved for future use.	
Pole Calc Fault 50	Generated if the calculated value of [Motor Poles] is less than 2 or greater than 32.	Check [Motor NP RPM] and [Motor NP Hertz] programming.
Power Loss Fault 03	DC bus voltage remained below 85% of nominal for longer than 0.500ms. [Line Loss Fault] parameter is set to "enabled."	Monitor the incoming AC line for low voltage or line power interruption.
Power Mode Fault 26	The internal power mode variable received an incorrect value.	Check all connections to the Control Board. Replace the board, Language Module, or complete drive as required.

Table 2.A (continued)
1336 PLUS Fault Descriptions

Name & Fault #	Description	Action
Power Overload 64	The drive rating of 150% for 1 minute has been exceeded.	Reduce load.
Power Test Flt 46	The internal power mode variable received an incorrect value.	Check all connections to the Power/Driver Board. Replace the board or complete drive as required.
Precharge Fault 19	Occurs if precharge device is open 20ms after the end of a line loss condition or if the bus charging alarm remains on for 20 seconds (precharge did not complete).	All larger frames – Check the precharge circuit. Replace the input SCRs, SCR Firing Board, Power Driver Board or complete drive as needed.
Precharge Open 56	The precharge circuit was commanded to close, but was detected to be open.	All larger frames – Check the precharge circuit. Replace the input SCRs, SCR Firing Board, Power Driver Board or complete drive as needed.
Reprogram Fault 48	The drive was commanded to write default values to EEPROM.	1. Clear the fault or cycle power to the drive. 2. Program the drive parameters as needed. Important: If [Input Mode] has been changed from its original value, power must be cycled before the new value will take affect.
ROM or RAM Flt 68	Internal power-up ROM or RAM tests have not executed properly.	Check Language Module. Replace Control Board or complete drive as required.
Run Boost Fault 34	An attempt has been made to set the [Run Boost] parameter to a value greater than the [Start Boost] parameter.	Verify that parameter has been programmed correctly.
Serial Fault 10	A SCANport adapter has been disconnected and the [Logic Mask] bit for that adapter is set to "1."	1. If no adapter was intentionally disconnected, check wiring to the SCANport adapters. Replace wiring, SCANport expander, SCANport adapters, Main Control Board or complete drive as required. 2. If an adapter was intentionally disconnected and the [Logic Mask] bit for that adapter is set to "1", this fault will occur. To guard against this fault occurring, set the [Logic Mask] bit for the adapter to "0."
Shear Pin Fault 63	Programmed [Current Limit] amps has been exceeded and [Shear Pin Fault] is enabled.	Check load requirements and [Current Limit] setting.

Table 2.A (continued)
1336 PLUS Fault Descriptions

Name & Fault #	Description	Action
Temp Sense Open 55	Heat sink thermistor is open or malfunctioning.	Check thermistor and connections.
Undervolt Fault 04	DC Bus voltage fell below the minimum value (388V DC at 460V AC input). [Line Loss Fault] and [Low Bus Fault] set to "enabled."	Monitor the incoming AC line for low voltage or line power interruption.
UV Short Fault 41	Excessive current has been detected between these two output terminals.	Check the motor and external wiring to the drive output terminals for a shorted condition.
UW Short Fault 42	Excessive current has been detected between these two output terminals.	Check the motor and external wiring to the drive output terminals for a shorted condition.
VW Short Fault 43	Excessive current has been detected between these two output terminals.	Check the motor and external wiring to the drive output terminals for a shorted condition.
Xsistr Desat Flt 47	One or more of the output transistors were operating in the active region instead of desaturation. This can be caused by excessive transistor current or insufficient base drive voltage.	Check for damaged output transistors. Replace output transistors, Power Driver Board or complete drive as needed.

Table 2.B Fault Code Cross Reference

Fault #	Display Name	Reset/Run
02	Auxiliary Fault	Yes
03	Power Loss Fault	Yes
04	Undervolt Fault	Yes
05	Overvolt Fault	Yes
06	Motor Stall Fault	Yes
07	Overload Fault	Yes
08	Overtemp Fault	Yes
09	Open Pot Fault	No
10	Serial Fault	No
11	Op Error Fault	No
12	Overcurrent Flt	Yes
13	Ground Fault	No
19	Precharge Fault	No
22	Drive Fault Reset	Yes
23	Loop Overrn Flt	Yes
24	Motor Mode Flt	Yes
26	Power Mode Fault	Yes
28	Timeout Fault	No
29	Hertz Err Fault	No
30	Hertz Set Fault	No
31	Timeout Fault	No
32	EEPROM Fault	No
33	Max Retries Fault	No
34	Run Boost Fault	No
35	Neg Slope Fault	No

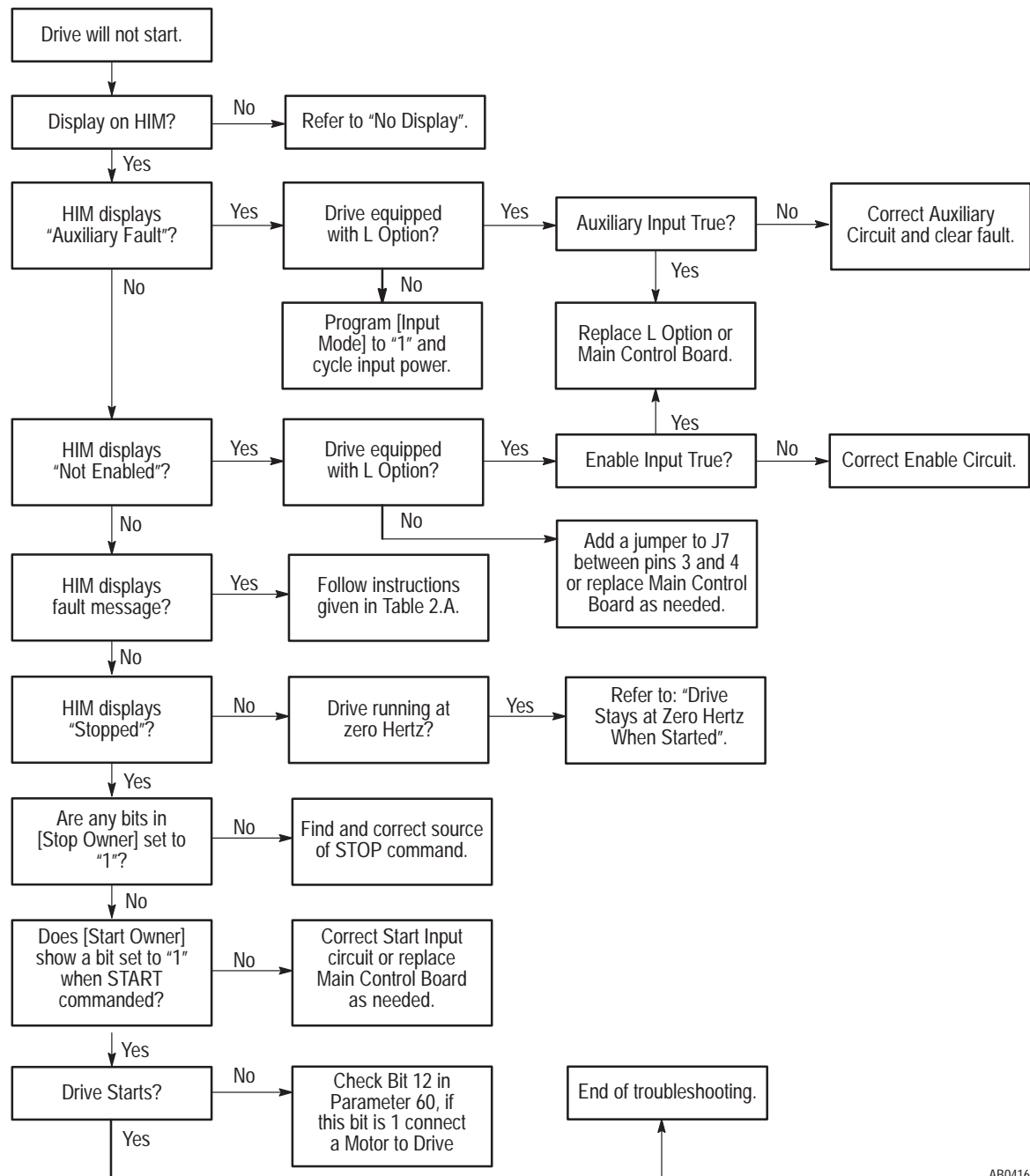
Table 2.B (continued)
Fault Code Cross Reference

Fault #	Display Name	Reset/Run
36	Diag C Lim Flt	No
37	P Jump Err Flt	No
38	Phase U Fault	No
39	Phase V Fault	No
40	Phase W Fault	No
41	UV Short Fault	No
42	UW Short Fault	No
43	VW Short Fault	No
46	Power Test Flt	No
47	Xsistr Desat Flt	No
48	Reprogram Fault	No
50	Pole Calc Fault	No
51	BGND 10ms Over	Yes
52	FGND 10ms Over	Yes
53	EE Init Read	No
54	EE Init Value	No
55	Temp Sense Open	No
56	Precharge Open	No
57	Ground Warning	No
58	Blwn Fuse Flt	No
63	Shear Pin Fault	No
64	Power Overload	No
65	Adptr Freq Err	No
66	EEprom Checksum	No
68	ROM or RAM Flt	No

Diagnostic Procedures by Symptom

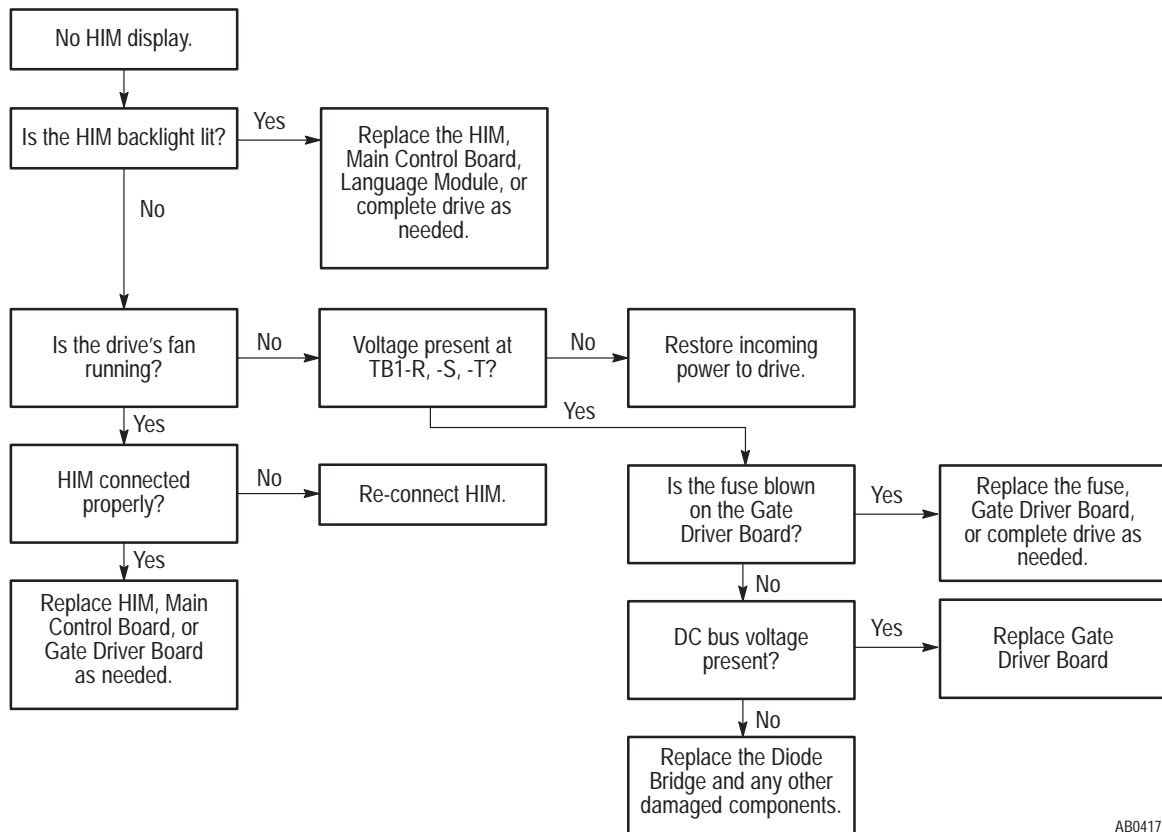
These charts list drive symptoms, symptom descriptions, and recommended actions to remedy the symptoms.

Drive Will Not Start



AB0416C

No Display

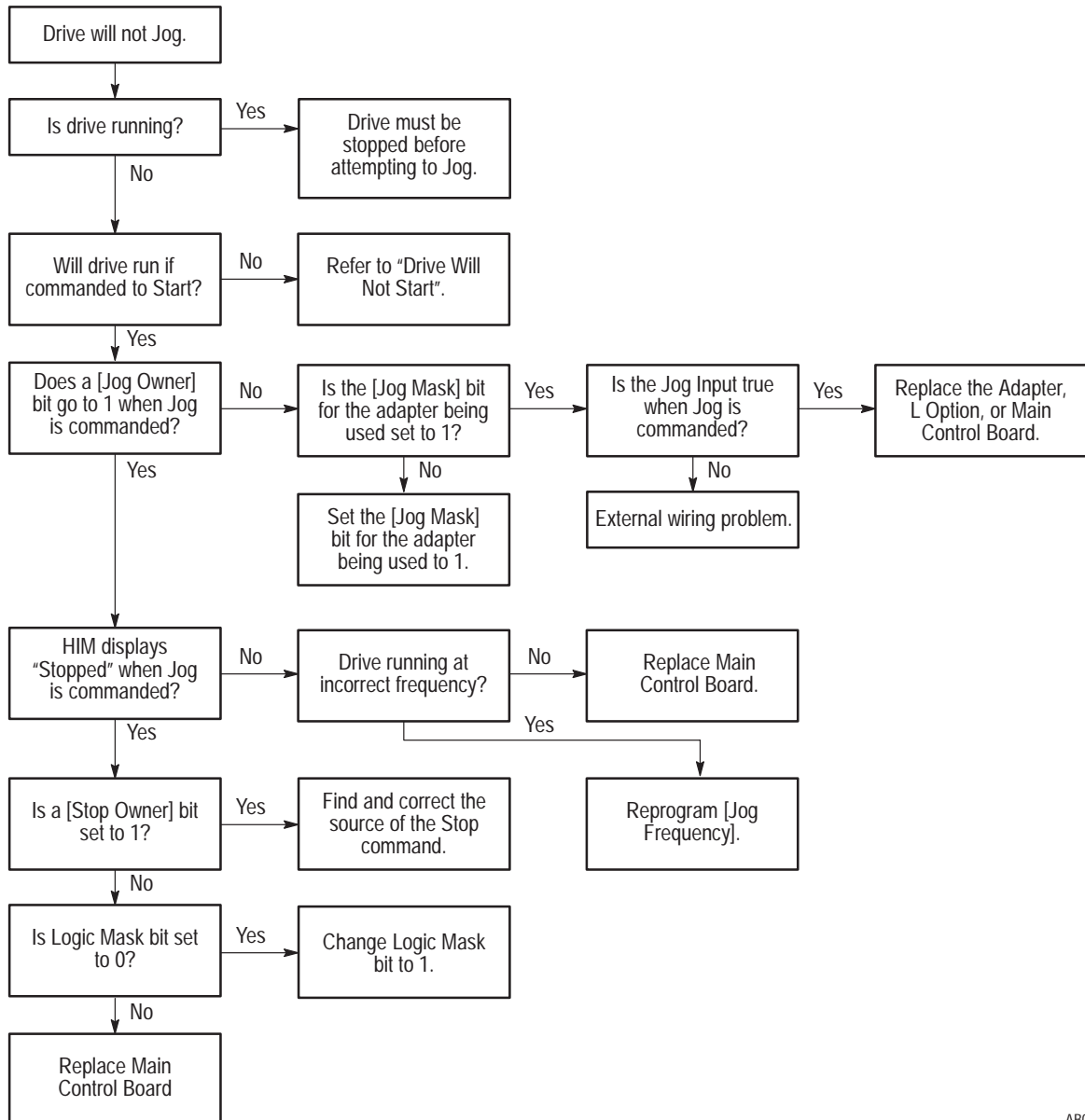


AB0417B

Drive Will Not Jog

Local Human Interface Module used to control drive.

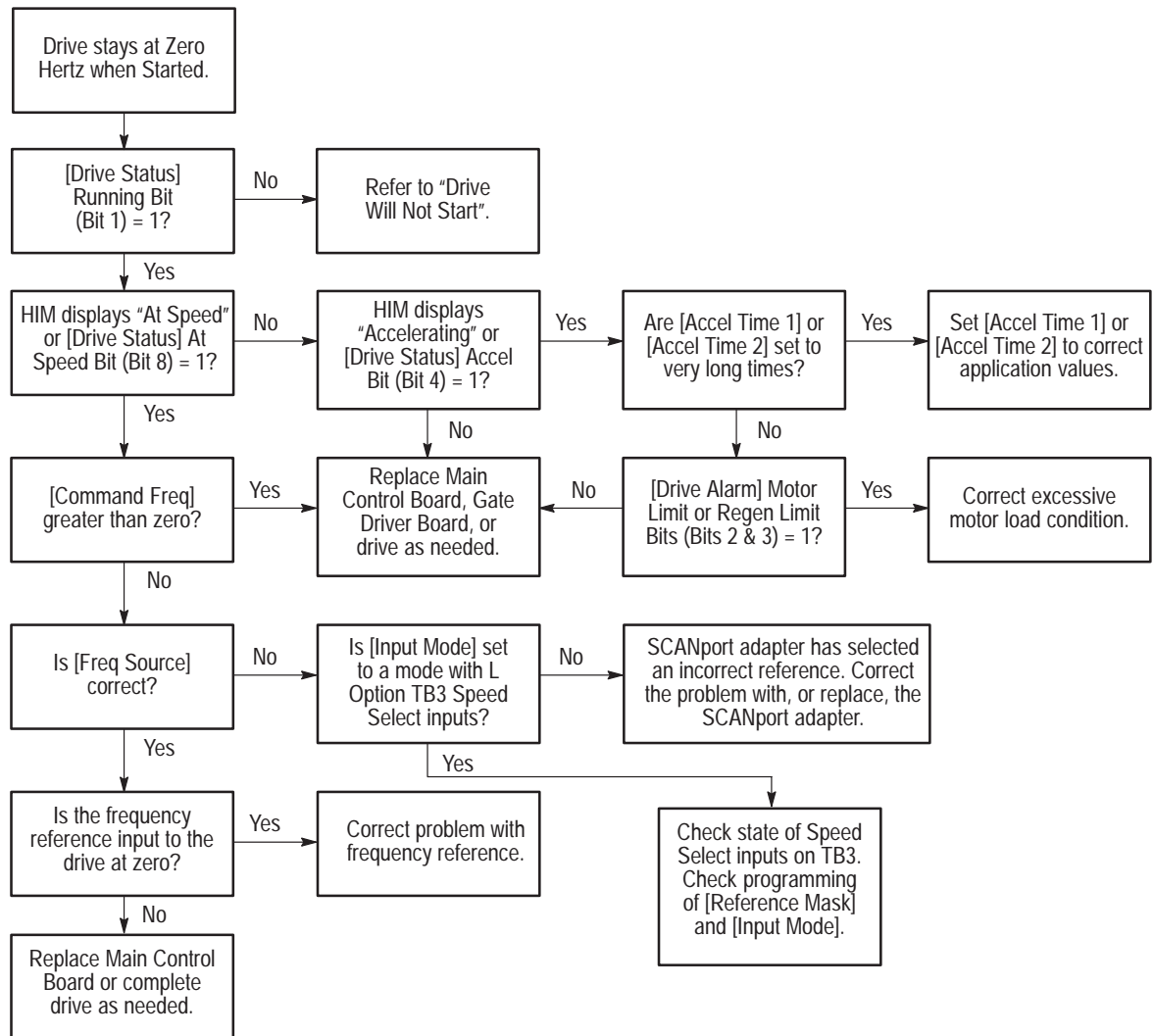
JOG is not active if a START command is present. START command always overrides a JOG command.



AB0418A

Drive Stays at Zero Hertz When Started

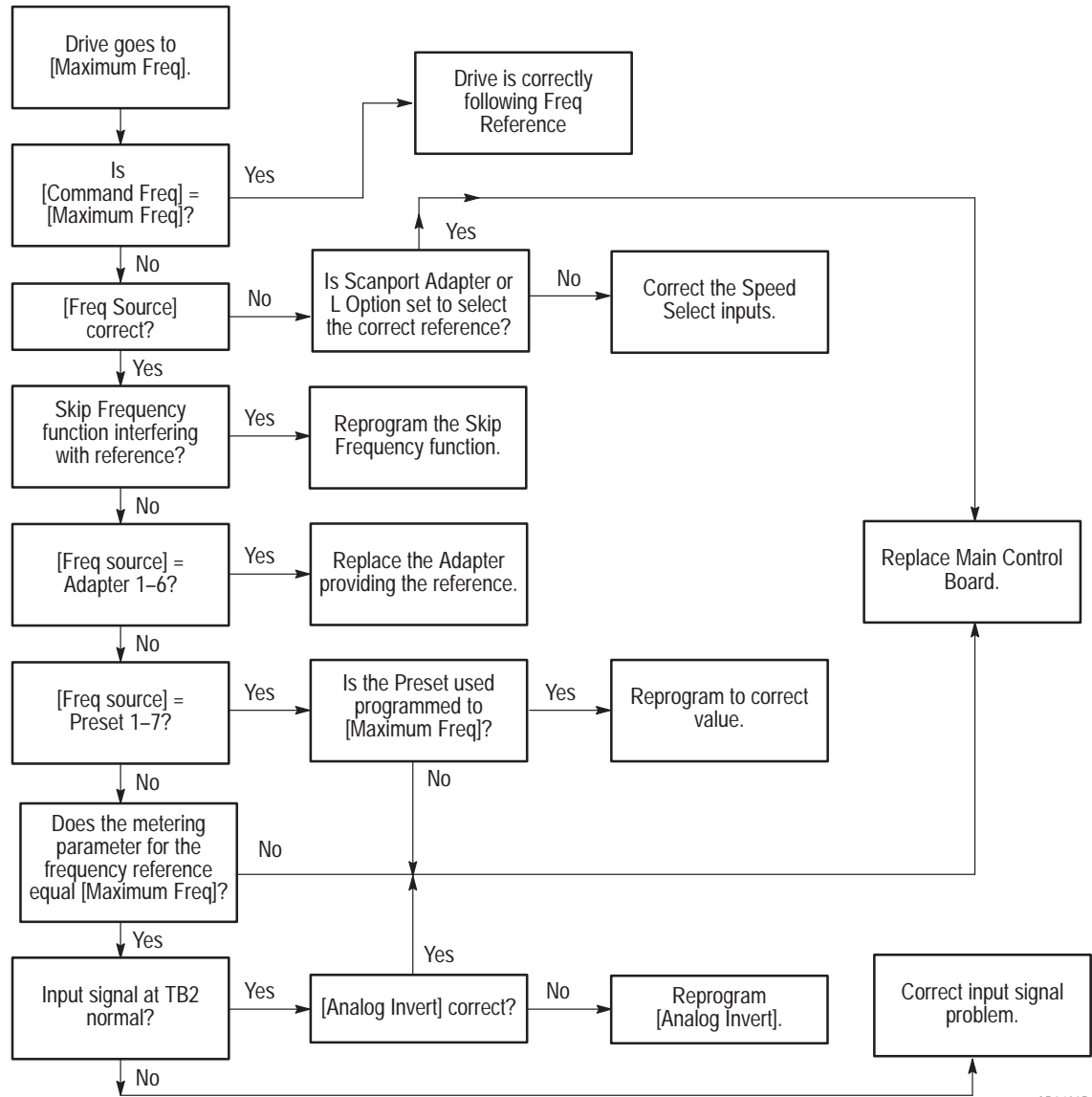
Important: [Command Frequency] parameter in the Metering Group can be checked using the HIM.



AB0419A

Drive Goes to Max Frequency

Important: [Command Frequency] parameter in the Metering Group can be checked using the HIM.



AB0420B

Clearing Faults

After correcting a fault, you can clear a fault from the drive in one of three ways:

1. Cycle the input power to the drive.
2. Press the Stop button. This works only if [Fault Clear Mode] is set to "Enabled".
3. Issue a reset command from a serial device.

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Disassembly and Access Procedures

Chapter Objectives

This chapter describes general disassembly procedures required to access internal drive components.

Disassembly and Access Overview



ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove and lock out power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Servicing energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment may cause death or serious injury. Follow the safety-related practices of NFPA 70E, Electrical Safety for Employee Workplaces, when working on or near energized equipment. Do not work alone on energized equipment.

Electrostatic Discharge Precautions



ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Rockwell Automation Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

Tools

You need the following tools to disassemble and assemble the drive:

- Pliers
- Phillips screwdrivers (small, medium, and large)
- Standard screwdrivers (small, medium, and large)
- 25/64-inch or 10 mm socket
- 7/16-inch or 11 mm socket
- 33/64-inch or 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in lb-in. or N-m
- Nylon tie wraps

Fastener Torque Specifications

Torque Sequence

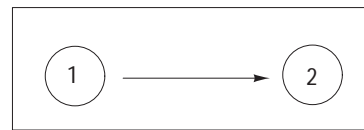
When mounting components to a drive's heat sink, component-fastener torque sequences and tolerances are crucial to component-to-heat sink heat dissipation.



ATTENTION: Component can be damaged if temporary tightening procedure is not performed to specification.

The following illustrates temporary and final tightening sequences for components fastened to a heat sink using two, four, and six screws. Temporary torque is 1/3 (33%) of final torque, except six-point mountings, which require 0.5 N-m (4 lb-in.). The numeric illustration labels are for your assistance. Drive components do not carry these labels.

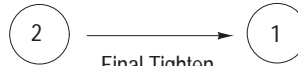
Figure 3.1 Two-Point Mounting



Two-Point Mounting



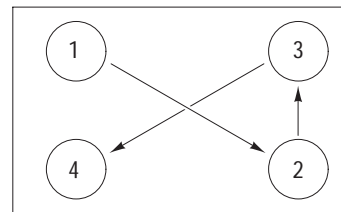
Temporary Tighten



Final Tighten

AB0016A

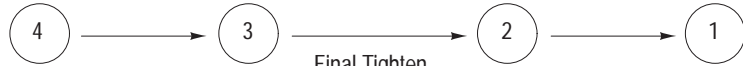
Figure 3.2 Four-Point Mounting



Four-Point Mounting



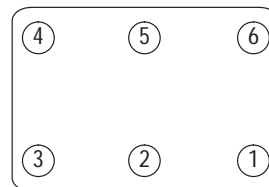
Temporary Tighten



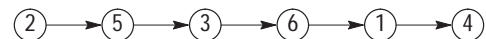
Final Tighten

AB0017A

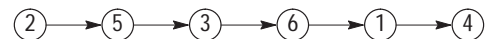
Figure 3.3 Six-Point Mounting



Six Point Mounting



Temporary Tighten to 0.5 N-m (4 lb-in.)



Final Tighten to 3 N-m (26 lb-in.)

AB0433B

Important: Do not exceed 0.5 Newton-meters (4 lb-in.) on initial torque of all six screws.

Torque Specifications

The following table lists fastener locations by component, how the fasteners are used, and torque specifications. Refer to Torque Sequence in this chapter for fastening two-point, four-point and six-point components to the heat sink.

Table 3.A Fastener Torque Specifications

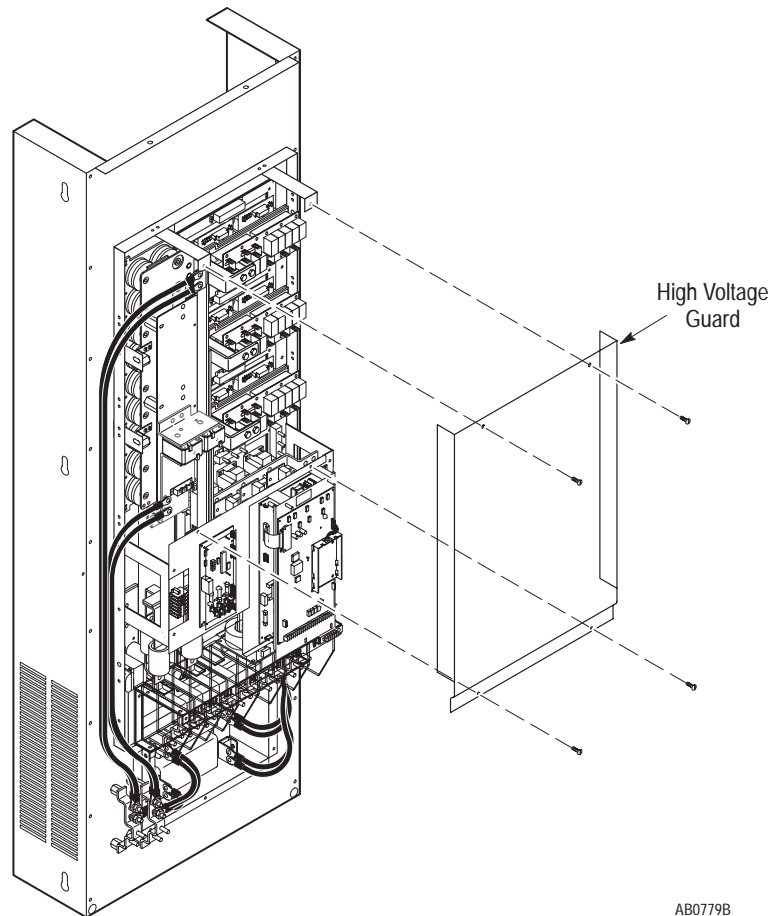
Component	Fastener Application	Torque lb-in.	Torque N-m
Fan Motor	Motor to Fan Cover Assembly	14	2
Fan Cover Assembly	Assembly to chassis	26	3
Fan Transformer	Transformer to chassis	26	3
Fan Capacitor	Capacitor to chassis	Hand-tighten	
MOV Surge Suppressor	MOV to chassis	14	2
Snubber Resistor	Resistor to heat sink	26	3
Snubber Resistor	Wires to Capacitor Bus Bar Assembly	50	6
Snubber Bracket	Bracket to Power Module	80	9
Snubber Board	Board to Brackets	50	6
Snubber Board	Board to Input Rectifier	50	6
Volt Sharing Resistor	Resistor to heat sink	26	3
Volt Sharing Resistor	Wires to Capacitor Bus Bar Assembly	50	6
Thermistor	Thermistor to heatsink	14	2
Bus Capacitor Holder	Holder to Bus Capacitors	26	3
Capacitor Bus Bar Assembly	Assembly to Bus Capacitors	50	6
Power Module Gate Interface Board	Board to Power Modules	14	2
Power Module Bus Bar	Bus Bar to Power Modules	80	9
Power Module	Module to heat sink	Refer to Figure 3.3	
DIN Rail (TB1)	Rail to chassis	50	6
PE Shortening Bar	Bar to TB1	80	9
Input Rectifier	Rectifier to heat sink	50	6
Input Fuse	Fuse to Input Bus Bar	208	23
Transitional Bus Bar Assembly	Assembly to Power Module Bus Bar Assembly	208	23
Bus Fuse F1	Fuse to Transitional Bus Bar Assembly	80	9
DC Bus Inductor L1	Inductor to chassis	50	6
Bus Bar Cable Adaptor	Adaptor to Transitional Bus Bar Assembly and DC Bus Inductor	208	23
Converter Bus and Motor Bus Bars	Bus Bars to all connections	208	23
Wires (PE)	Wires to Ground Stud	80	9
Wires	Wires to TB1	80	9
Wire (TE)	Wire to TB1	50	6
Wires	Wires to TB2	7	0.8
Wires	Wires to TB3	8 – 10	0.9 – 1.1
LEM Mounting Plate	Mounting Plate to LEM Clamping Plate	14	2
Power Cables	Cables to terminals	208	23
Control Board Platform	Plates to chassis	26	3
High Voltage Guard	Guard to chassis	26	3

Disassembly and Access Procedures

Removing the High Voltage Guard

The High Voltage Guard is a clear plastic guard covering the Bus Capacitor Bank and the Power Module Assembly.

Figure 3.4 High Voltage Guard



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the four nuts fastening the High Voltage Guard to the standoffs.
4. Pull the guard away from the drive.

Installation

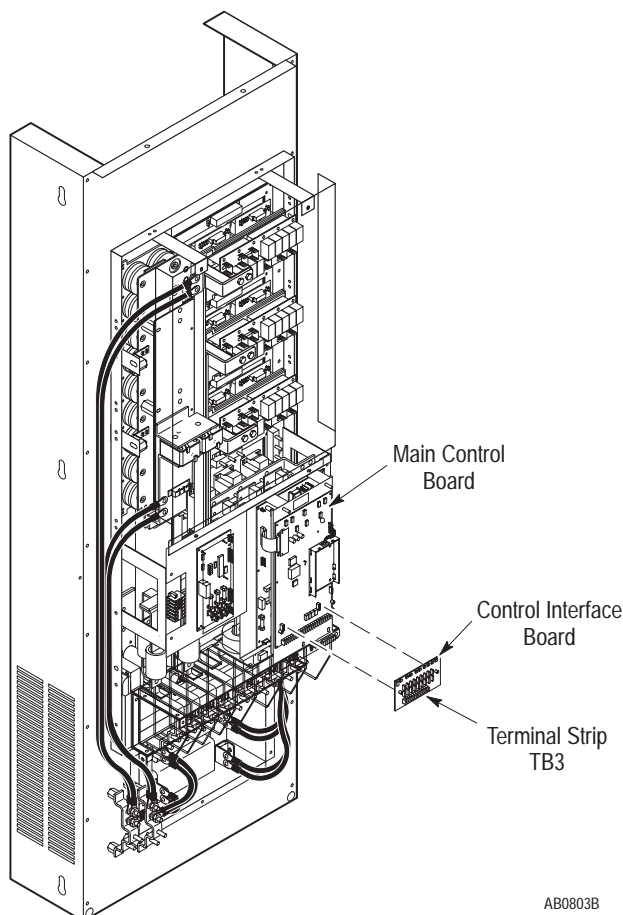
Install the High Voltage Guard in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing Control Interface Board MOD-L4, -L5, or -L6

Figure 3.5 Control Interface Board



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove all wires from the terminals on TB3.
4. Loosen the two captive screws fastening the Control Interface Board to the Main Control Board.
5. Grip the right and left sides of the Control Interface Board and pull the board straight outward from the Main Control Board.

Installation

Install the Control Interface Board in reverse order of removal.

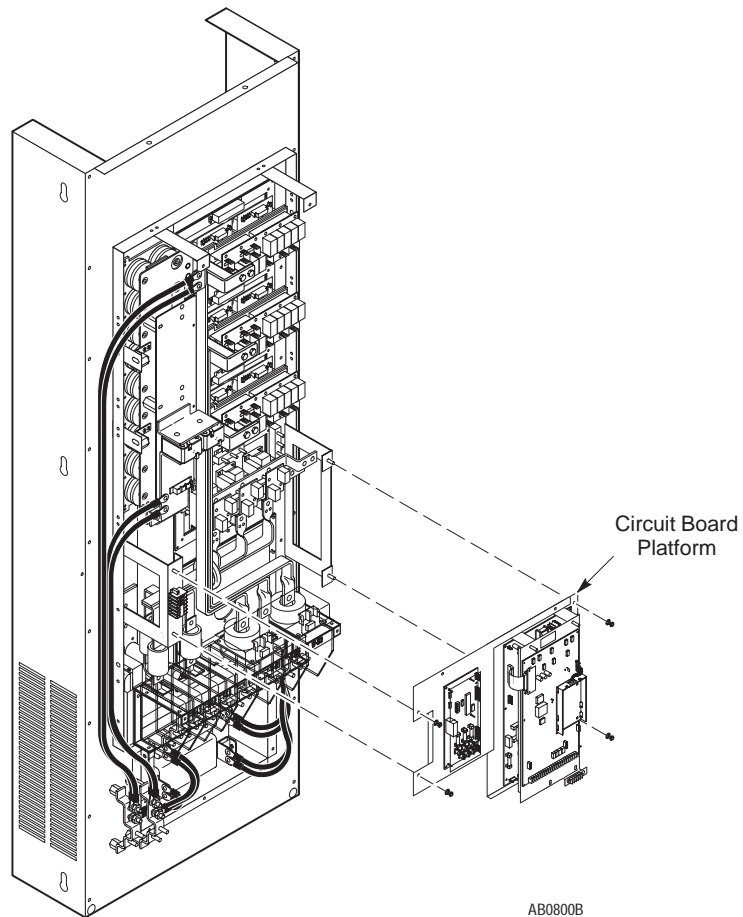


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing the Circuit Board Platform

The Circuit Board Platform contains the Main Control Board, the Gate Driver Board, and the Precharge Board.

Figure 3.6 Circuit Board Platform



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Disconnect both ground wires from TB5 located in the lower right-hand corner of the the Main Control Board Mounting Plate.
4. Disconnect the following from the Main Control Board:
 - J1 connector
 - J2 connector
 - TB3, if Control Interface Board is used
 - any optional boards
5. Remove the two nuts from the top and the bottom of the Main Control Board Mounting Plate.
6. Pull the Main Control Board Mounting Plate straight out and remove the plate from the drive.
7. Disconnect the following from the Gate Driver Board:
 - J2 connector
 - J7 connector
 - J8 connector
 - J10 connector
8. Disconnect the following from the Precharge Board:
 - J1 connector
 - J2 connector
 - J4 connector
9. Disconnect the two LEM wire harness plugs.
10. Remove the four nuts fastening the Circuit Board Platform to the drive.
11. Pull the Circuit Board Platform straight out and remove the platform from the drive.

Installation

Install the Circuit Board Platform in reverse order of removal.



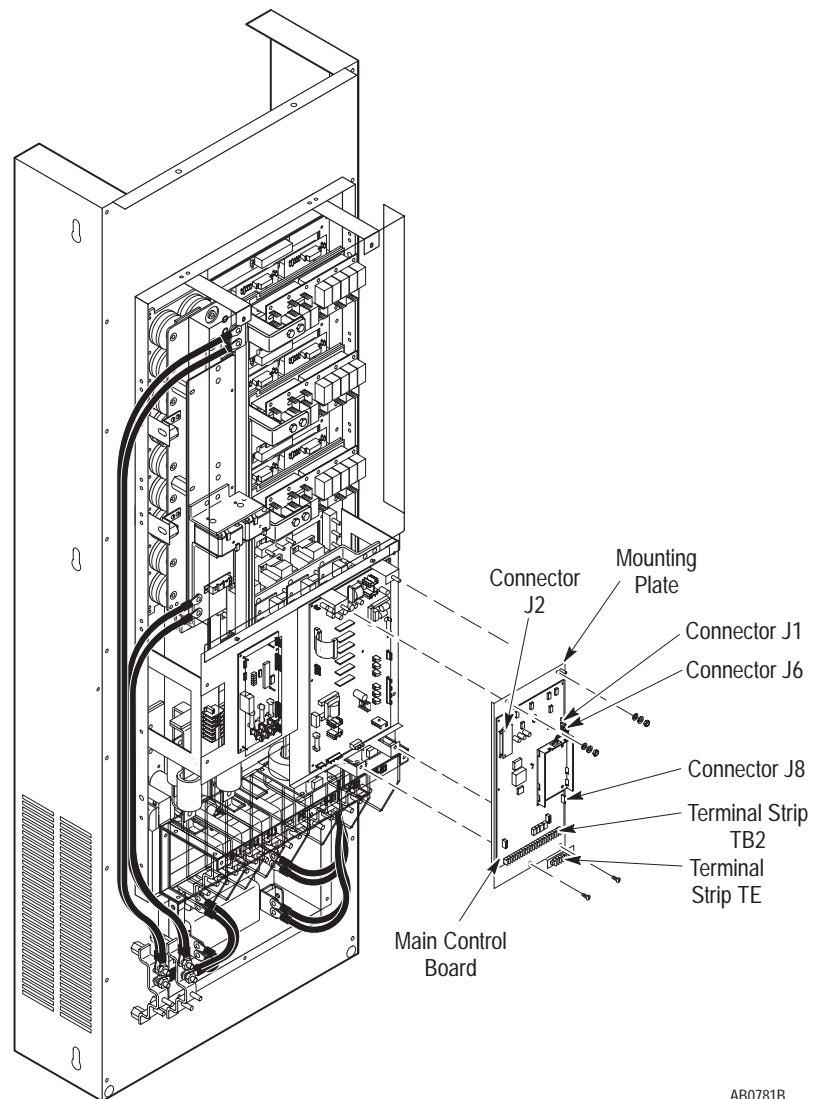
ATTENTION: When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing the Main Control Board Mounting Plate

Figure 3.7 Main Control Board Mounting Plate



AB0781B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Disconnect the following from the Main Control Board:
 - J1 connector
 - J2 ribbon cable connector
 - J8 connector
 - Ground wires from terminal strip TE
4. Remove the two screws fastening the bottom of the Main Control Board Mounting Plate to the Circuit Board Platform.
5. Remove the nuts fastening the top of the Main Control Board Mounting Plate to the Circuit Board Platform.
6. Lift the Main Control Board Mounting Plate out of the drive.

Installation

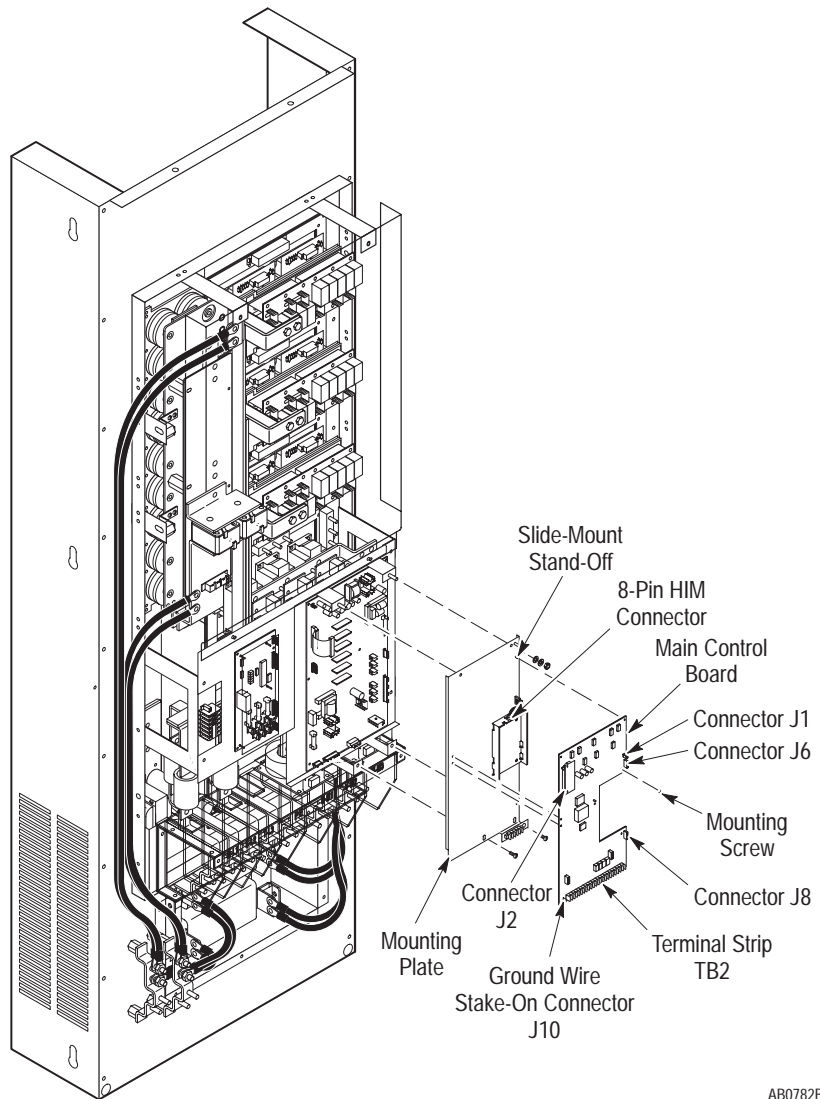
Install the Main Control Board Mounting Plate in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing the Main Control Board from the Mounting Plate

Figure 3.8 Main Control Board and Mounting Plate



AB0782B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove all wires from terminal strip TB3 if a Control Interface Board is used.
4. Disconnect the following from the Main Control Board:
 - J1 connector
 - J2 ribbon cable connector
 - J6 connector
 - J8 connector
 - 8-pin connector from HIM Mounting Plate
 - Ground wire at stake-on connector J10
 - All wires from terminals on TB2
5. Remove the five screws fastening the Main Control Board to the mounting plate.
6. Slide the Main Control Board toward the top of the drive to release it from the slide-mount stand-offs.
7. Lift the Main Control Board away from the mounting plate.

Installation

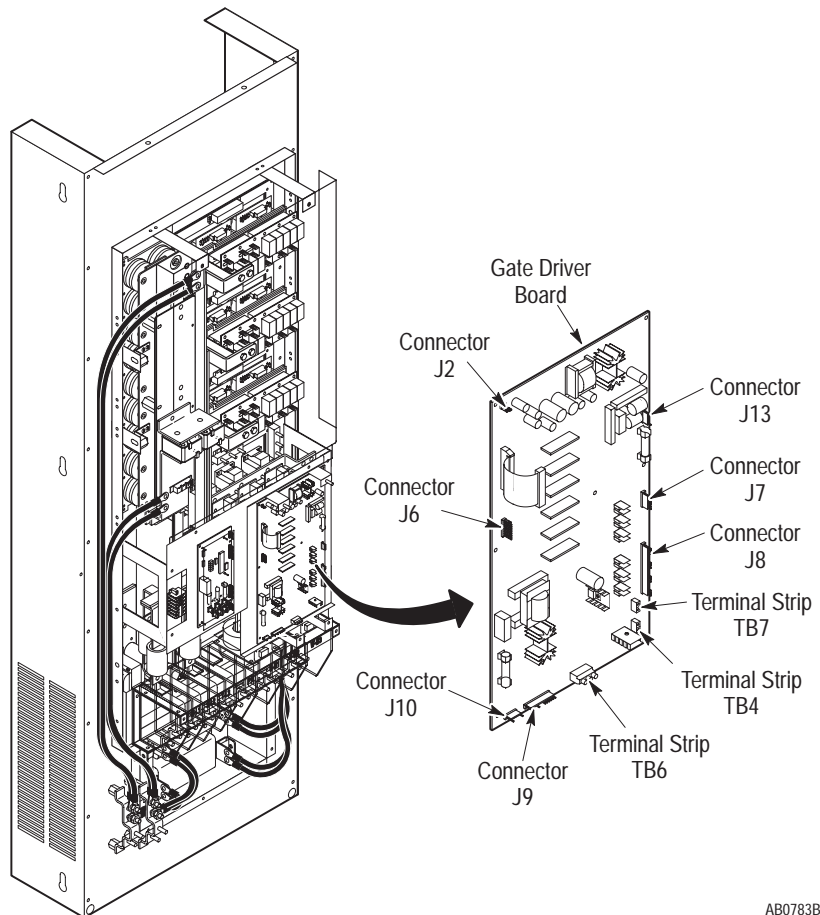
Install the Main Control Board in reverse order of removal.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing the Gate Driver Board from the Mounting Plate

Figure 3.9 Gate Driver Board and Mounting Plate



AB0783B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the Main Control Board Mounting Plate. Refer to Removing the Main Control Board Mounting Plate in this chapter.
4. Disconnect the following from the Gate Driver Board:
 - J2 connector
 - J6 connector
 - J7 connector
 - J8 connector
 - J9 connector
 - J10 connector
 - J13 connector
 - TB4 – 24 VDC Auxiliary Input
 - Ground wire from TB7 on the Gate Driver Board
5. Turn the eight standoff screws, fastening the Gate Driver Board to the mounting plate, 1/4 turn counterclockwise.
6. Pull the Gate Driver Board away from the mounting plate.

Installation

Install the Gate Driver Board in reverse order of removal.



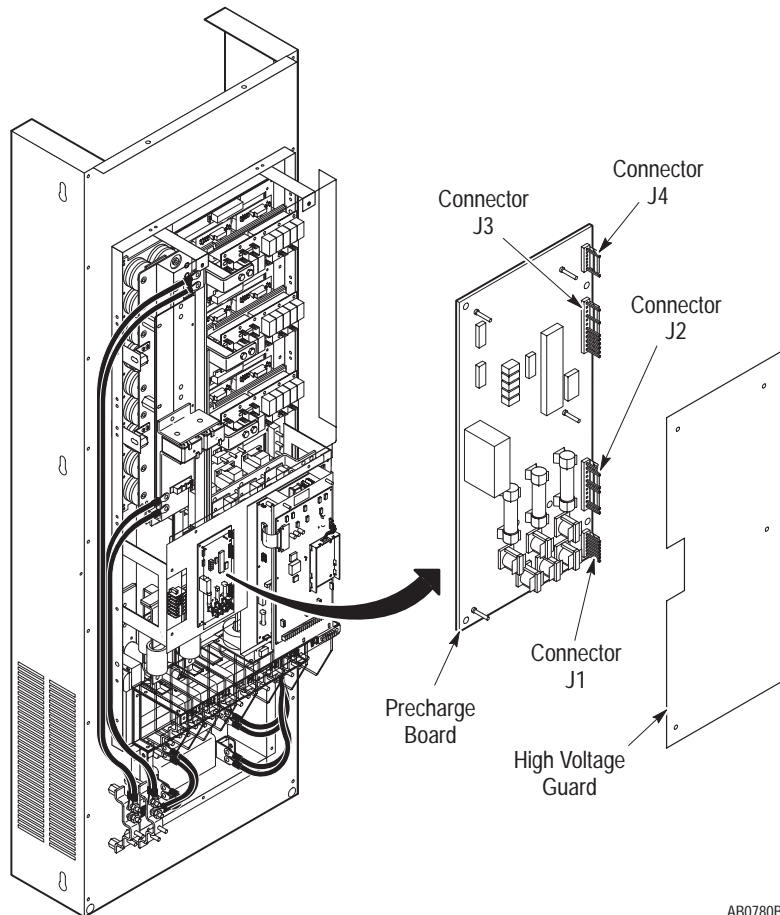
ATTENTION: When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing the Precharge Board from the Mounting Plate

Figure 3.10 Precharge Board



AB0780B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Disconnect the following from the Precharge Board:
 - J1 connector
 - J2 connector
 - J3 connector
 - J4 connector
4. Pull the Precharge High Voltage Guard away from the four nylon spacers.
5. Turn the six standoff screws, fastening the Precharge Board to the mounting plate, 1/4 turn counterclockwise.
6. Pull the Precharge Board away from the mounting plate.

Installation

Install the Precharge Board in reverse order of removal.



ATTENTION: When removing the entire wire harness connecting Gate Driver Board connector J9 to Precharge Board connector J3, align the wires on the harness terminals with the pins on the board connectors. Incorrect harness connection may result in faulty drive operation and may damage the equipment.

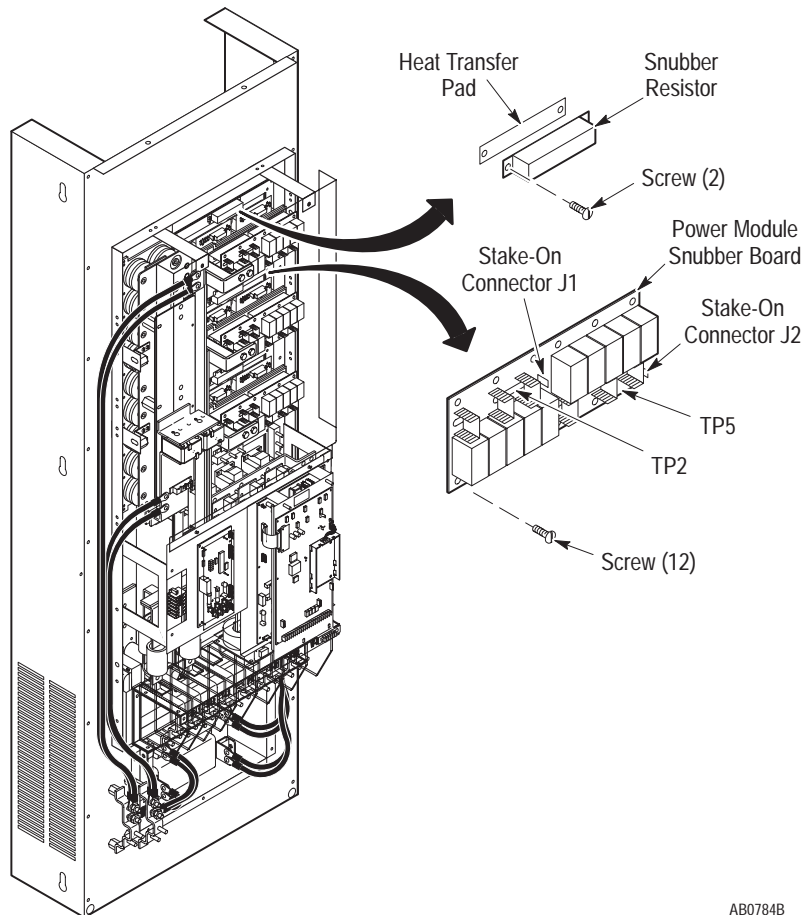


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing a Power Module Snubber Board

The Power Module Snubber Boards are located on the upper right side of the chassis.

Figure 3.11 Power Module Snubber Board



AB0784B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus to discharge any voltage.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard. Refer to Removing the High Voltage Guard in this chapter.
4. Measure the DC voltage from TP5 on the Power Module Snubber Board to TP2 (-DC Bus). If voltage greater than 50 VDC is still present, follow the directions in the Electric Shock Hazard Attention shown above.
5. Remove the Snubber Resistor wire from the Power Module Snubber Board stake-on connectors J1 and J2.
6. Remove the twelve screws fastening the Power Module Snubber Board to the snubber bracket to remove the snubber boards.
7. Check Snubber Resistor with VOM. The reading should be 8 ohms. If open, replace resistor.

Installation



ATTENTION: Do not substitute longer or shorter hardware when fastening the Power Module components to the Power Modules. Use the same size fastener to fasten the components as was originally used. Using different fastener lengths will damage the Power Modules.

Install the Snubber Board in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.

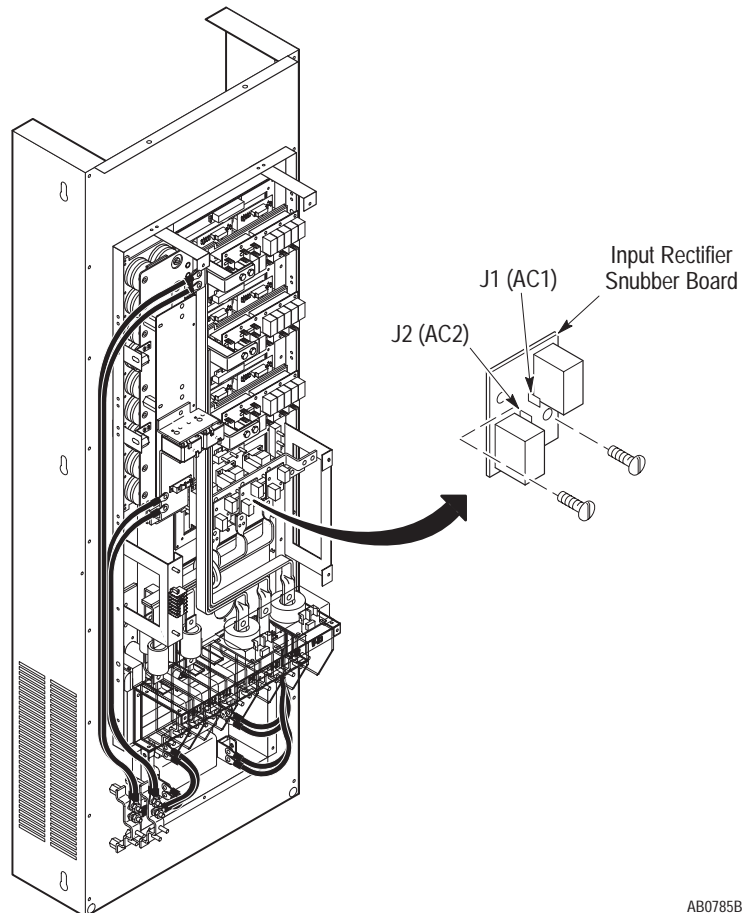


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Removing an Input Rectifier Snubber Board

The Input Rectifier Snubber Boards are located under the Circuit Board Platform.

Figure 3.12 Input Rectifier Snubber Board



AB0785B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the Circuit Board Platform. Refer to Removing the Circuit Board Platform in this chapter.
4. Remove the wire from Input Rectifier Snubber Board stake-on connectors J1 (AC1) and J2 (AC2).
5. Remove the two screws fastening the Snubber Board to the Converter Bus Bar.

Installation

Install the Snubber Board in reverse order of removal. Refer to Table 3.A – Fastener Torque Specifications.

Important: Verify that the snubber resistor wiring is reconnected to the proper phase snubber board.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Accessing Power Plane Components

To access the power plane components located on the chassis, refer to Removing a Power Module Snubber Board in this chapter.

Component Test Procedures

Chapter Objectives

The following tests help you troubleshoot BP250 – BP450 drives.

Component Test Overview

In some cases, different tests troubleshoot components of the same name.

These similar tests vary according to the rating of the drive being tested. Verify that the rating on the drive matches the rating for the test you are performing.



ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove and lock out power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/–DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Servicing energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment may cause death or serious injury. Follow the safety-related practices of NFPA 70E, Electrical Safety for Employee Workplaces, when working on or near energized equipment. Do not work alone on energized equipment.

Electrostatic Discharge Precautions



ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Rockwell Automation Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

Tools

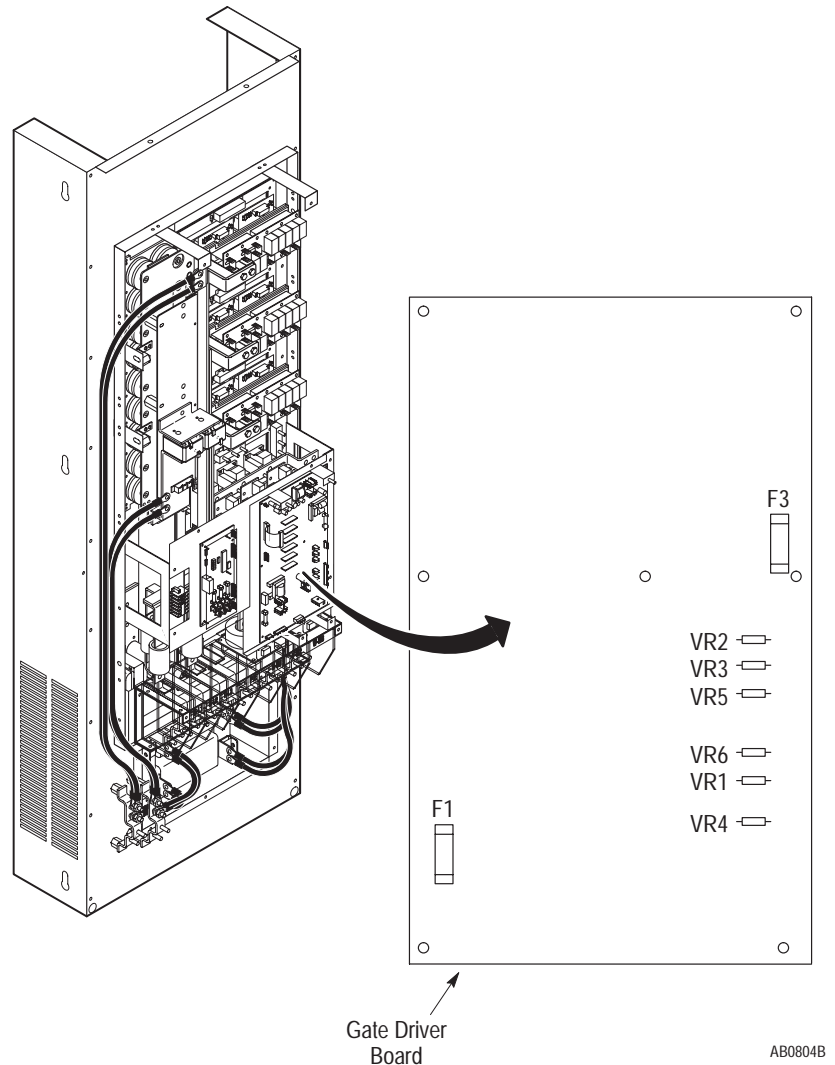
You need the following tools to disassemble and assemble the drive:

- Pliers
- Phillips screwdrivers (medium and large)
- Standard screwdrivers (small, medium, and large)
- 25/64-inch or 10 mm socket
- 7/16-inch or 11 mm socket
- 33/64-inch or 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in lb-in. or N-m
- Nylon tie wraps

Test 1 – Testing the Gate Driver Board

The Gate Driver Board is located beneath the Main Control Board. If modules have been replaced, you must test the Gate Driver Board.

Figure 4.1 Gate Driver Board Test



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the Main Control Board Mounting Plate. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Main Control Board Mounting Plate.
4. Unplug the connectors from the Gate Driver Board.
5. Set your meter to test resistance.
6. Test Fuses F1 and F3 for an open condition. Replace the Gate Driver Board if either fuse shows an open condition.
7. Set your meter to test diodes.
8. Test VR1 – VR6. The following table shows meter connections at the components and ideal meter readings for those connections. Refer to Figure 4.1 for component locations.

Table 4.A Gate Driver Board Test

Component	Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading *
VR1	+	-	1.06
	-	+	1.8
VR2	+	-	1.06
	-	+	1.8
VR3	+	-	1.06
	-	+	1.8
VR4	+	-	1.06
	-	+	1.8
VR5	+	-	1.06
	-	+	1.8
VR6	+	-	1.06
	-	+	1.8

Note: Typical malfunction is shorted in both directions.

* Meter Used: Fluke® Model 87, set to "Diode" range.

9. Replace the Gate Driver Board if your readings do not match the table readings. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Gate Driver Board.

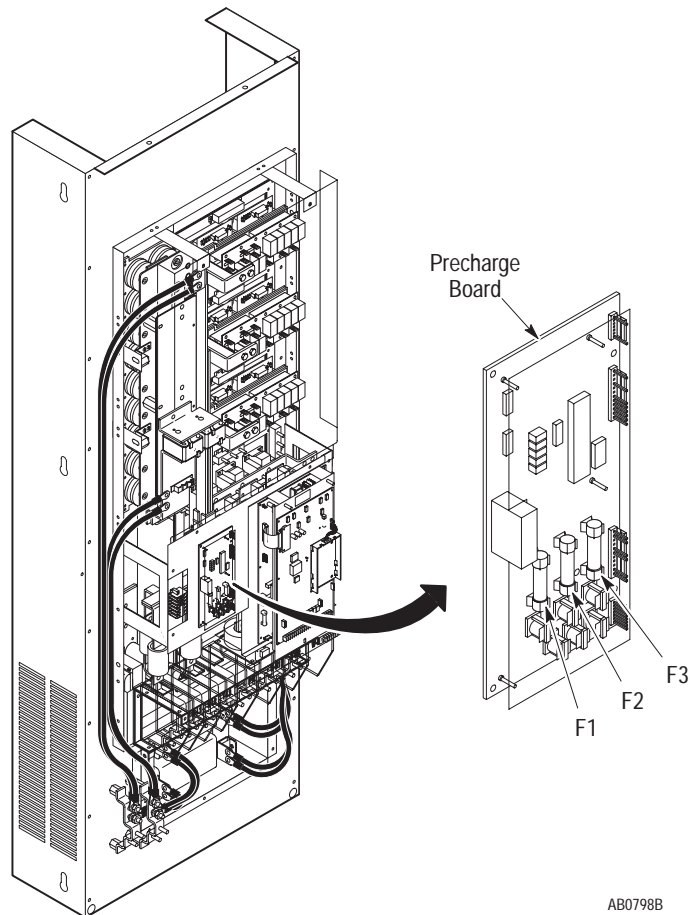


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Test 2 – Testing the Precharge Board

If Input Rectifier modules have been replaced, you must check the Input Rectifier Snubber Board and the Precharge Board. Refer to Chapter 3 – Disassembly and Access Procedures, Removing an Input Rectifier Snubber Board and Removing the Precharge Board.

Figure 4.2 Precharge Board Test



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Set your meter to test resistance.
4. Test fuses F1, F2, and F3 through the access holes in the Precharge Board High Voltage Guard and check for open conditions.
5. Replace the Precharge Board if any fuse shows an open condition. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Precharge Board.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

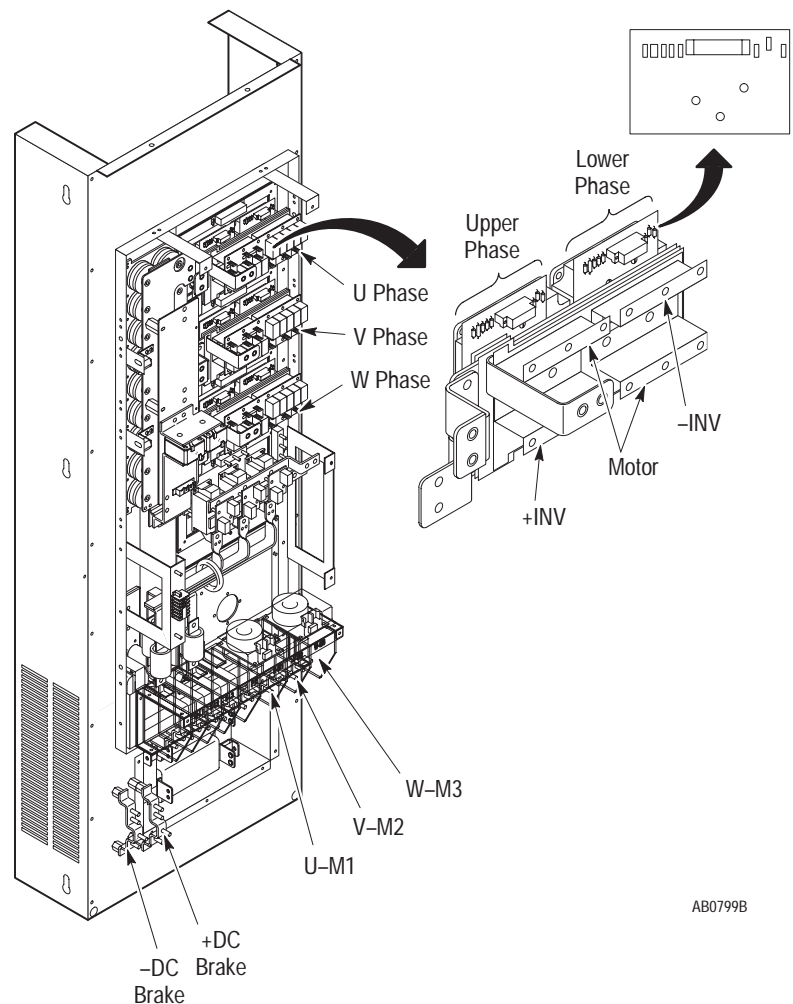
Test 3 – Testing the Power Modules

The Power Modules are located on the upper right side of the heat sink. If modules have been replaced, you must check the Power Module Snubber Board. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus to discharge any voltage. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.

Figure 4.3 Power Module Test



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ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the motor leads from TB1-U, V and W terminals of the drive.
4. Set your meter to test diodes.
5. Test the output sections of the drive. This should indicate if any of the drive's output phases has a problem. Table 4.B shows meter connections and ideal meter readings for those connections. Refer to Figure 4.3 for meter connection locations.

Table 4.B Output Sections

Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading	Phase with Problem
+DC Brake	U-M1	Infinite	U
+DC Brake	V-M2	Infinite	V
+DC Brake	W-M3	Infinite	W
U-M1	+DC Brake	0.318	U
V-M2	+DC Brake	0.318	V
W-M3	+DC Brake	0.318	W
-DC Brake	U-M1	0.318	U
-DC Brake	V-M2	0.318	V
-DC Brake	W-M3	0.318	W
U-M1	-DC Brake	Infinite	U
V-M2	-DC Brake	Infinite	V
W-M3	-DC Brake	Infinite	W

Note: Typical malfunction is shorted in both directions.

* Meter Used: Fluke® Model 87, set to "Diode" range.

6. If the readings are not approximately the same as in Table 4.B, the last column identifies the phase with a potential problem. If the readings are not correct, continue with the test procedure to check the individual phase or phases in question.

7. Remove the High Voltage Guard. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
8. Remove the Power Module Snubber Boards. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.
9. Test the Power Module Snubber Resistor. The Snubber Resistor will read 8.0 ohm with meter on resistance. Refer to Figure 4.4.
10. Test the Power Module phases that did not pass the Table 4.B tests. Table 4.C shows meter connections and ideal meter readings for those connections. Refer to Figure 4.3 for meter connection locations.

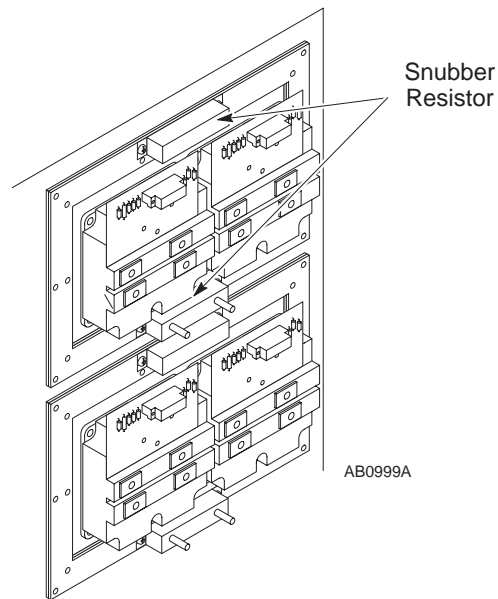
Table 4.C Power Modules

Upper Phase			
Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading	Type of Reading
Motor	+INV	0.289v	Diode
+INV	Motor	Infinite	Diode
E	TP1	0.289v	Diode
TP1	E	Infinite	Diode
E	Motor	0 ohms	Resistance
TP1	+INV	0 ohms	Resistance
E	R2	10k ohms	Resistance
Lower Phase			
Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading	Type of Reading
-INV	Motor	0.289v	Diode
Motor	-INV	Infinite	Diode
E	TP1	0.289v	Diode
TP1	E	Infinite	Diode
E	-INV	0 ohms	Resistance
TP1	Motor	0 ohms	Resistance
E	R2	10k ohms	Resistance

Note: Typical malfunction for diode test is shorted in both directions.

Note: Select meter to read appropriate type of measurement where needed.

* Meter Used: Fluke® Model 87, set to "Diode" range.

Figure 4.4 Power Module Snubber Resistors

- 11.** Replace the Power Module phase if the meter readings are not approximately as shown. Refer to Chapter 5 – Part Replacement Procedures, Power Modules.
- 12.** If one or more Power Modules is replaced, test the Gate Driver Board. Refer to Testing the Gate Driver Board in this chapter.

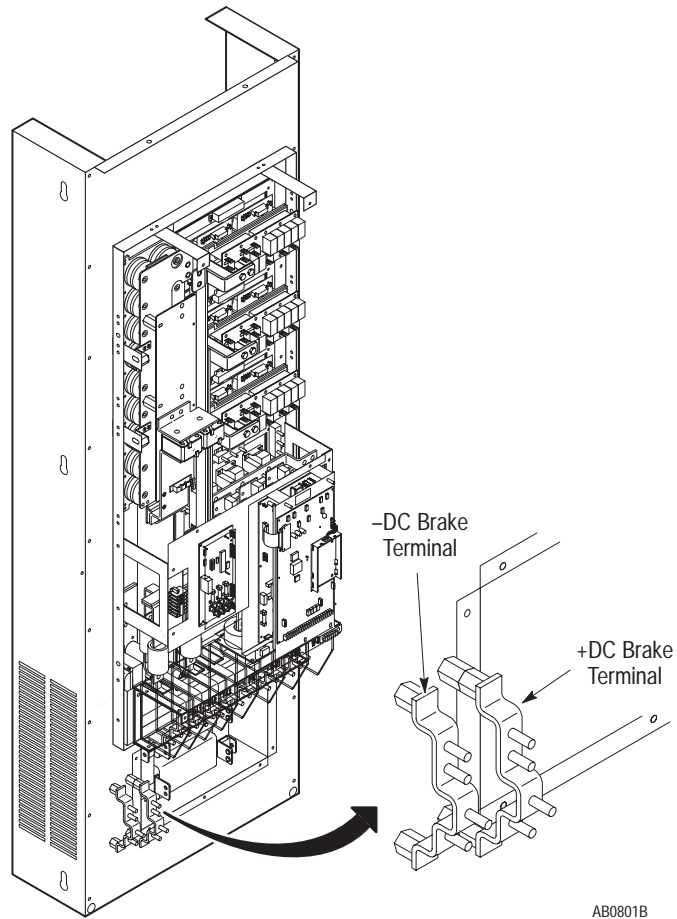


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Test 4 – Testing the Bus Capacitors

The Bus Capacitor Bank is located on the upper left side of the Main Chassis.

Figure 4.5 Bus Capacitor Bank Test



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Set your meter to test DC voltage.
4. Connect the negative lead of your meter to the -DC Brake Terminal on TB1 and the positive lead to the +DC Brake Terminal. Refer to the following tables and Figure 4.5 for meter readings and terminal locations.



ATTENTION: Servicing energized industrial control equipment can be hazardous. Electrical shock, burns, or unintentional actuation of controlled industrial equipment may cause death or serious injury. Follow the safety-related practices of NFPA 70E, Electrical Safety for Employee Workplaces, when working on or near energized equipment. Do not work alone on energized equipment.

5. Apply power **AFTER** the meter is connected, otherwise your meter will read zero volts. Expand readings for all input voltage ratings.

Table 4.D Bus Capacitor Bank Test

Drive Rating	Input Volts	Meter Reading
A	200	283V DC +/-10%
	230	325V DC +/-10%
	240	339V DC +/-10%
B	380	537V DC +/-10%
	415	587V DC +/-10%
	480	679V DC +/-10%
C	500	707V DC +/-10%
	575	813V DC +/-10%
	600	848V DC +/-10%

6. If the voltage is out of tolerance, check the following:
 - An open condition at an Input Rectifier.
 - A voltage drop due to Bus Inductor L1 resistance.
 - A voltage drop between an Input Rectifier and the bus capacitors due to loose or resistive wires or connections.
 - Precharge circuit problems.
7. If the above check does not reveal a problem, replace the Bus Capacitor Bank and Load-Sharing Resistors. Refer to Chapter 5 – Part Replacement Procedures, Bus Capacitor Bank.

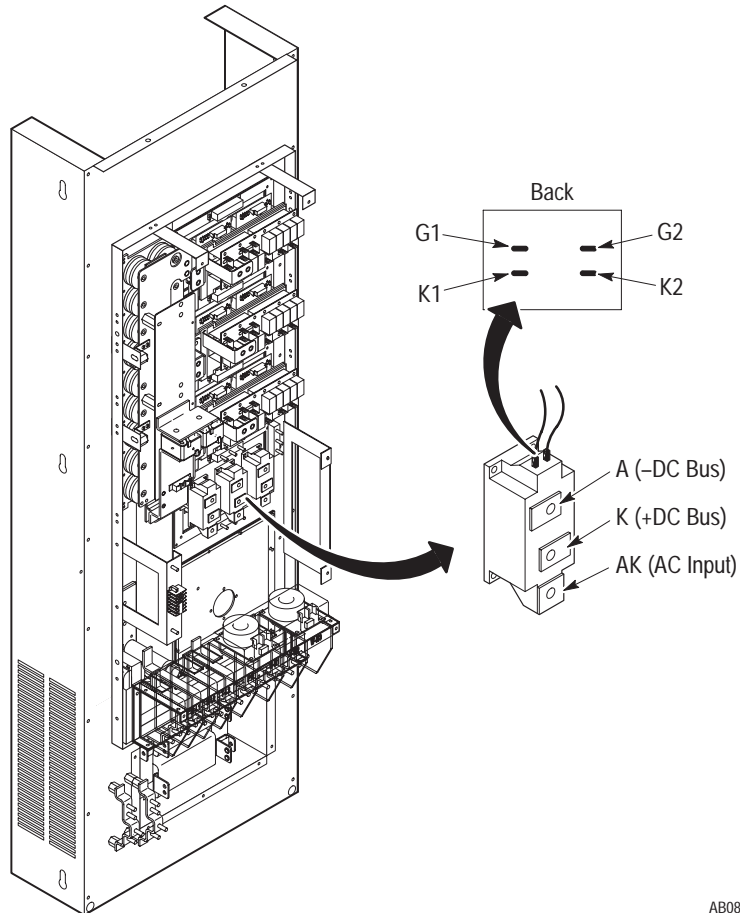


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Test 5 – Testing the Input Rectifiers

The Input Rectifiers are located on the bottom of the heat sink.

Figure 4.6 Input Rectifier Test



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ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.

3. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
4. Remove the Input Rectifier Snubber Board. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Input Rectifier Snubber Board.
5. Set your meter to test diodes.
6. The following table shows meter connections and ideal meter readings for those connections. Refer to Figure 4.6 for meter connection locations.

Table 4.E Input Rectifier Test

Meter (+) Lead	Meter (-) Lead	Nominal Meter Reading
AK	K	Infinite
AK	A	Infinite
K	A	Infinite
K	AK	Infinite
A	AK	Infinite
A	K	Infinite
G1	K1	0.011
K1	G1	0.011
G2	K2	0.011
K2	G2	0.011

Note: Typical malfunction is shorted in both directions.

* Meter Used: Fluke® Model 87, set to "Diode" range.

7. Replace the Input Rectifier if any meter readings are not as shown. Refer to Chapter 5 – Part Replacement Procedures, Input Rectifiers.
8. If the Input Rectifier shorted, check the Power Modules for damage. Refer to Testing the Power Modules in this chapter.

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Part Replacement Procedures

Chapter Objective

This chapter describes procedures required to replace drive components. This chapter references Chapter 3 – Disassembly and Access Procedures for basic drive component access.

Safety Precautions



ATTENTION: Some printed circuit boards and drive components may contain hazardous voltage levels. Remove power before you disconnect or reconnect wires, and before you remove or replace fuses and circuit boards. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.

Electrostatic Discharge Precautions



ATTENTION: This assembly contains parts and sub-assemblies that are sensitive to electrostatic discharge. Static control precautions are required when servicing this assembly. Component damage may result if you ignore electrostatic discharge control procedures. If you are not familiar with static control procedures, reference Rockwell Automation Publication 8000-4.5.2, Guarding Against Electrostatic Discharge, or any other applicable ESD protection handbook.

Electrostatic discharge generated by static electricity can damage the complimentary metallic oxide semiconductor devices on various drive boards. It is recommended that you perform these procedures to guard against this type of damage when circuit boards are removed or installed:

- Wear a wrist-type grounding strap that is grounded to the chassis.
- Attach the wrist strap before removing the new circuit board from the conductive packet.
- Remove boards from the drive and immediately insert them into their conductive packets.

Tools

You need the following tools to disassemble and assemble the drive:

- Pliers
- Phillips screwdrivers (small, medium, and large)
- Standard screwdrivers (small, medium, and large)
- 25/64-inch or 10 mm socket
- 7/16-inch or 11 mm socket
- 33/64-inch or 13 mm deep-well socket
- 5/16-inch or 8 mm open-end wrench
- Torque wrench, metered in lb-in. or N-m
- Nylon tie wraps

Major Component Replacement

This section explains in detail how to replace the following drive components:

- Bus Capacitor Bank
- Thermistor
- Power Modules
- Bus Fuses F1
- Input Fuses
- Ground Fault CT
- Input Rectifiers
- LEMs
- MOV Surge Suppressor
- Fan and Transformer Assembly
- DC Bus Inductor L1

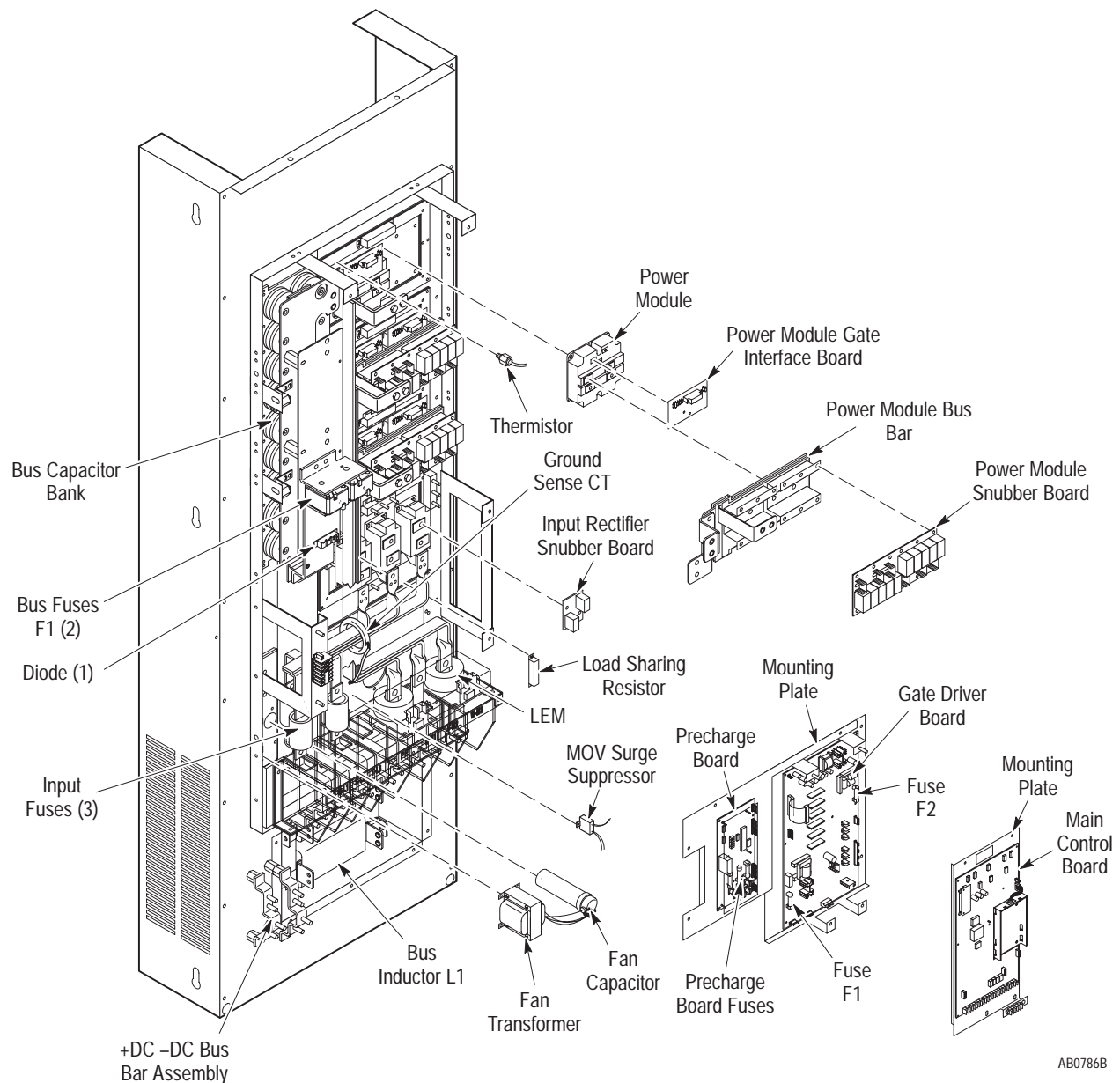
For Main Control Board, Gate Driver Board, Precharge Board, Snubber Boards, and Control Interface Board installation and removal procedures, refer to Chapter 3.

Detailed Product Identification

Rockwell Automation Adjustable Frequency AC Drives are modular by design to enhance troubleshooting and spare parts replacement, thereby helping reduce production down-time.

The following illustration calls out the main components of a typical drive. Component designs vary slightly among the different drive ratings, but component locations are identical.

Figure 5.1 Main Drive Components

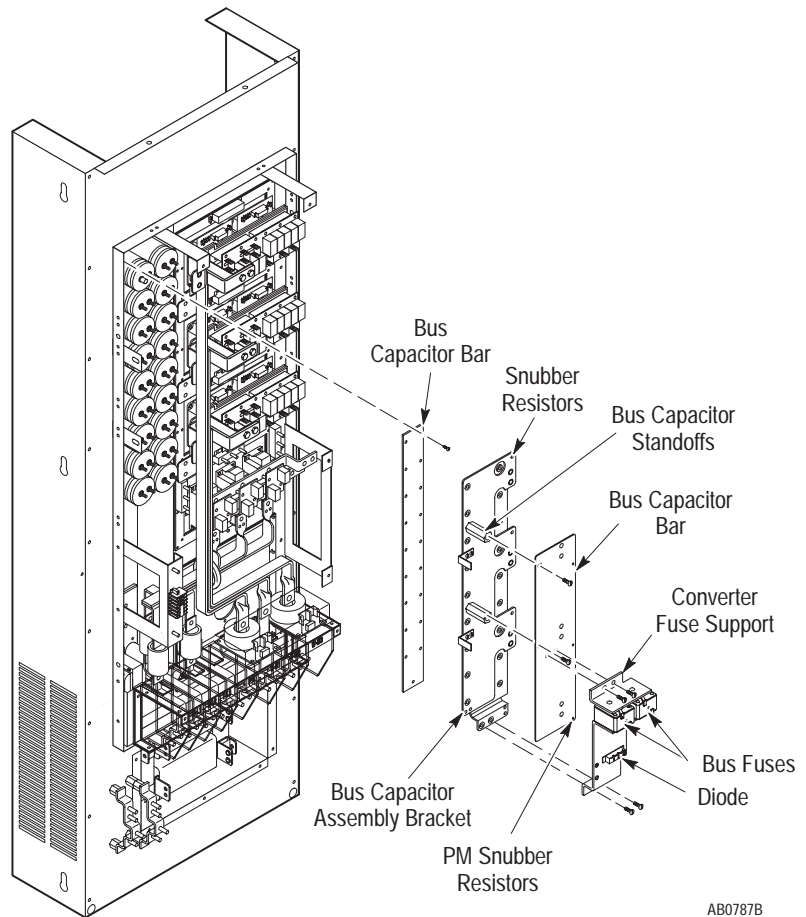


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Bus Capacitor Bank

The Bus Capacitor Bank is located on the upper left side of the Main Chassis.

Figure 5.2 Bus Capacitor Bank



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

Access the Main Chassis:

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.

Access the Bus Capacitor Bank:

1. Remove the (+) Bus Capacitor Bar:
 - A. Remove the two sets of bolts fastening the power cables to the top and bottom of the Bus Capacitor Bank.
 - B. Remove the four bolts fastening the Converter Fuse Support to the (+) Bus Capacitor Bar and Power Module Bus Bar.
 - C. Pull the Converter Fuse Support, with bus fuses attached, from the drive.
 - D. Remove the six bolts (2 per phase) fastening the (+) Bus Capacitor Bar to the Power Module Bus Bar.
 - E. Remove the two bolts fastening the (+) Bus Capacitor Bar to the Bus Capacitor Inverter Standoffs.
 - F. Remove the three screws fastening the (+) Bus Capacitor Bar to the Power Module Snubber Resistors.
 - G. Pull the (+) Bus Capacitor Bar from the drive.

2. Remove the Power Module Bus Bar:

- A.** Remove the six screws fastening the Power Module Bus Bar to the (–) Bus Capacitor Bar.
- B.** Remove the eighteen nuts fastening the Power Module Bus Bars to the (–) Bus Capacitor Bar.
- C.** Remove the five screws fastening the Power Module Bus Bar to the Snubber Resistors.
- D.** Remove the two bolts fastening the Power Module Bus Bar to the drive.
- E.** Pull the Power Module Bus Bar from the drive.

3. Remove the Bus Capacitors:

- A.** Remove the eighteen nuts fastening the (–) Bus Capacitor Bar to the Bus Capacitors.
- B.** Pull the (–) Bus Capacitor Bar from the drive.
- C.** Remove the Bus Capacitors from the drive.

Installation

- 1.** Fasten the capacitor assembly in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

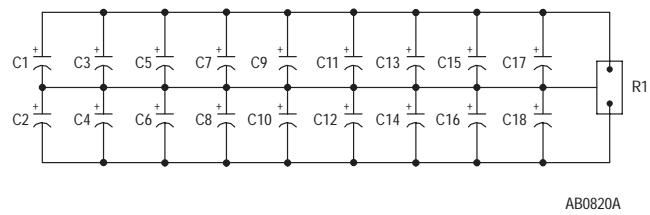
Important: Orient the notch and vent hole on the Bus Capacitors to the top of the drive.

- 2.** Connect the Load-Sharing Resistors to the Bus Capacitors according to the diagram in Figure 5.3. Refer to the schematic diagrams in this manual for more information on component configurations.

Important: Check the Load-Sharing Resistors for an open condition and replace any open resistors.

Important: If the drive is equipped with PEM nuts on the Cap Bus bar, use them instead of capacitor studs to make the electrical connection.

Figure 5.3 Load-Sharing Resistor Connections to Bus Capacitors



Important: 380/460V AC C1 – C18 are 400 VDC

Important: 500/600V AC C1 – C18 are 500 VDC

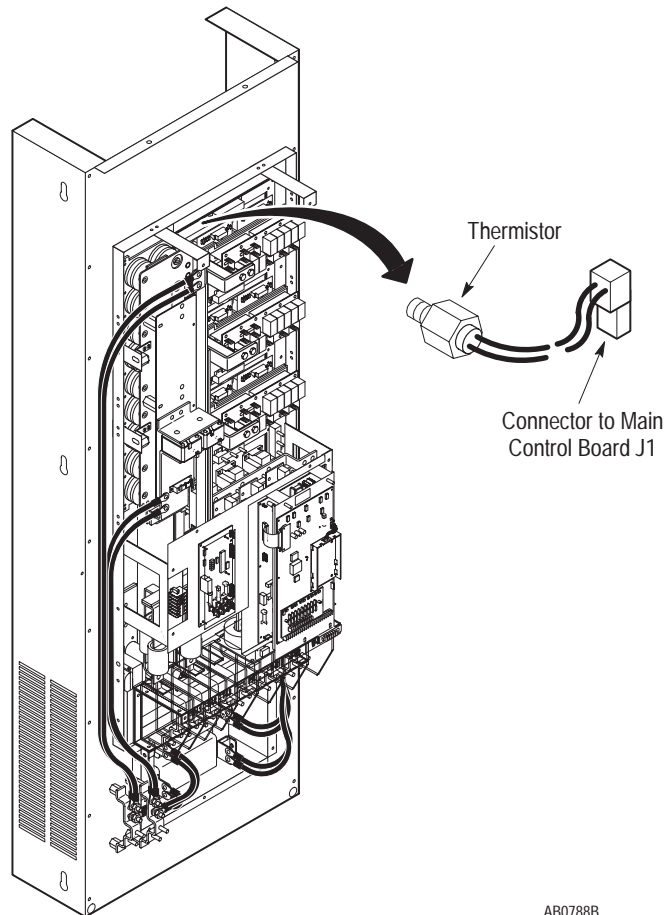


ATTENTION: Capacitors not installed correctly will erupt or vent and could cause injury and equipment damage. Observe correct polarities.

Thermistor

The Thermistor is located on the heat sink at the top-middle of the drive.

Figure 5.4 Thermistor



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Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the screws fastening the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Disconnect the Thermistor connector at J1 on the Main Control Board.
5. Unscrew the Thermistor from the heat sink.

Installation

Install the Thermistor in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

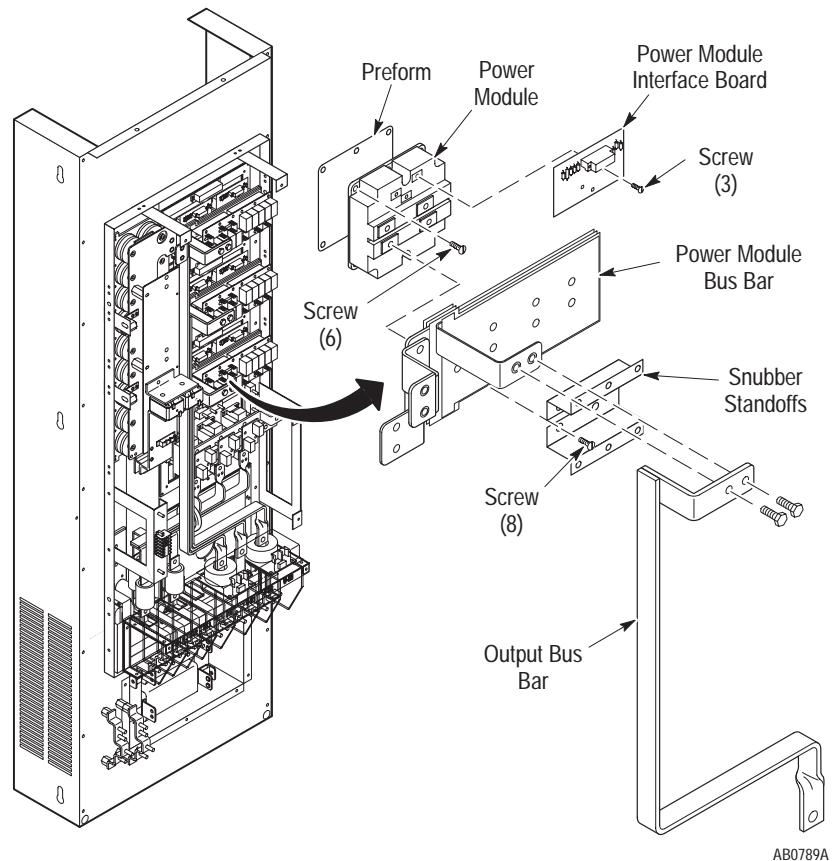


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Power Modules

The Power Modules are located near the top of the heat sink. If one or more Power Modules is replaced, you must check the Power Module Snubber Board and the Precharge Board. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Precharge Board.

Figure 5.5 Power Modules



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus to discharge any voltage. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/–DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
5. Remove the six bolts fastening the three Output Bus Bars to the Power Module Assembly and TB1.
6. Remove the Power Module Snubber Boards. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.
7. Remove the bolts fastening the Power Module Bus Bar to the Bus Capacitor Bank.
8. Remove the eight screws fastening the Snubber Standoffs to the Power Module Bus Bar. Remove the standoffs.
9. Slide the Power Module Bus Bar to the right and remove the bus bar from the drive.

10. Remove the three screws fastening the Power Module Interface Board to the Power Module.
11. Remove the six screws fastening the Power Module to the heat sink.
12. Pull the Power Module away from the heat sink.

Installation

1. Clean all surfaces between the Power Module and the heat sink using a soft, clean cloth.
2. Replace the Preform between the Power Module and the heat sink.
3. Install the Power Module in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

Important: Remove the copper shorting strip from the Power Module before replacing the Power Module Interface Board.



ATTENTION: Do not substitute longer or shorter hardware when fastening the Power Module components to the Power Modules. Use the same size fastener to fasten the components as was originally used. Using different fastener lengths will damage the Power Modules.

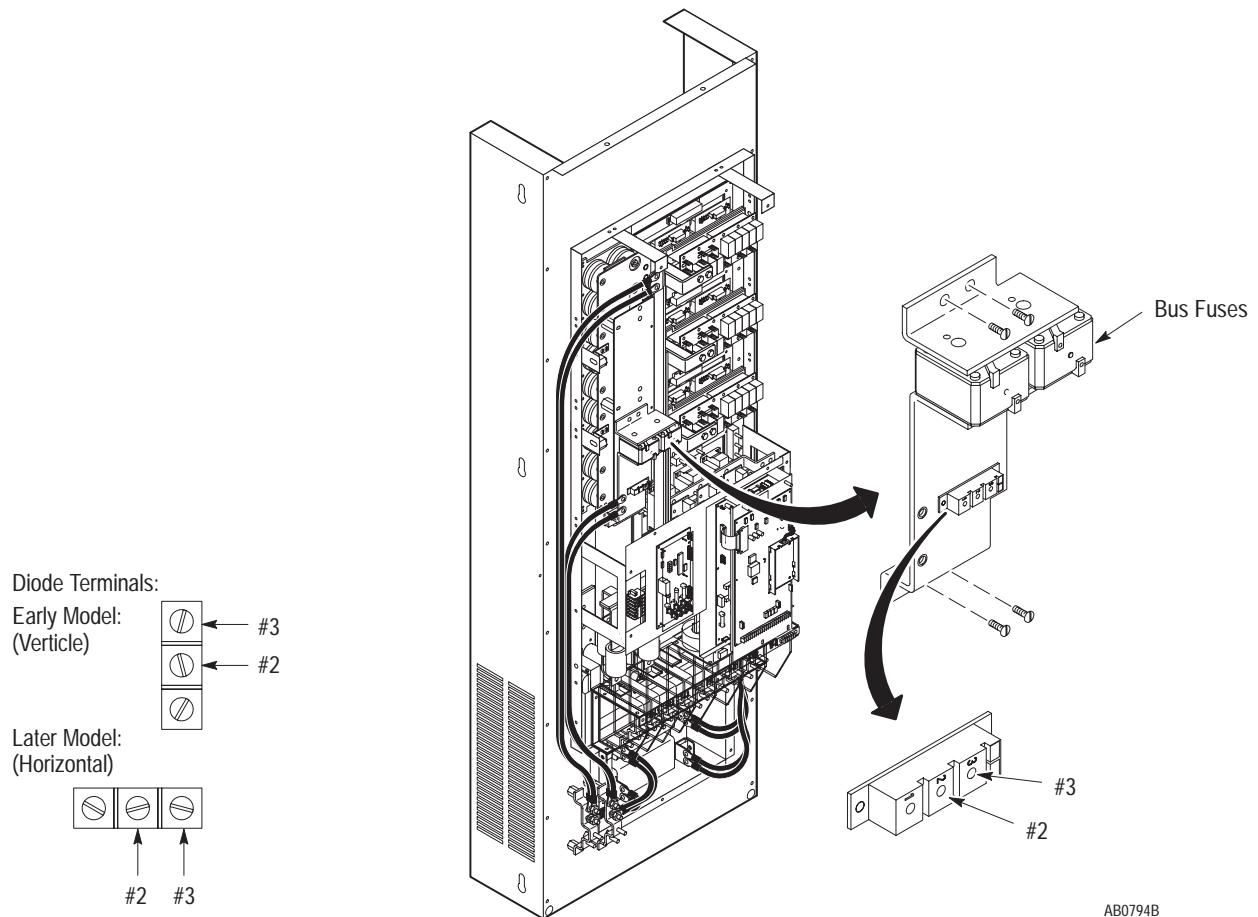


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Bus Fuses F1

The Bus Fuses are located on the Bus Capacitor Bank Assembly.

Figure 5.6 Bus Fuses F1



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the screws fastening the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the screws fastening the two Bus Fuses to the drive.
5. Pull the fuses out from the drive.

Important: When one fuse blows, you must replace both fuses. Also replace the Bus Fuse Diode Module in parallel. Bus Fuse/Diode Conversion kits also include new style Bus Bar.

Installation

Install the Bus Fuses in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

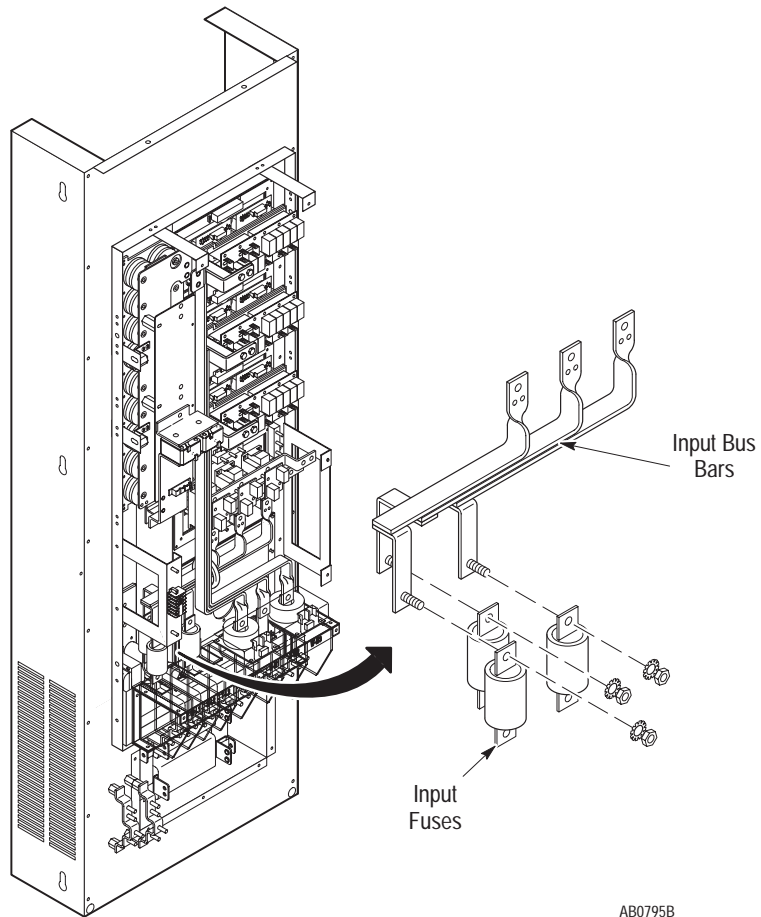


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Input Fuses

The Input Fuses are located on the bottom left-hand side of the chassis above TB1.

Figure 5.7 Input Fuses



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the nuts fastening the Input Fuse to the Input Bus Bar and TB1.
4. Pull the blown fuse out from the drive.

Installation

Install the Input Fuse in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

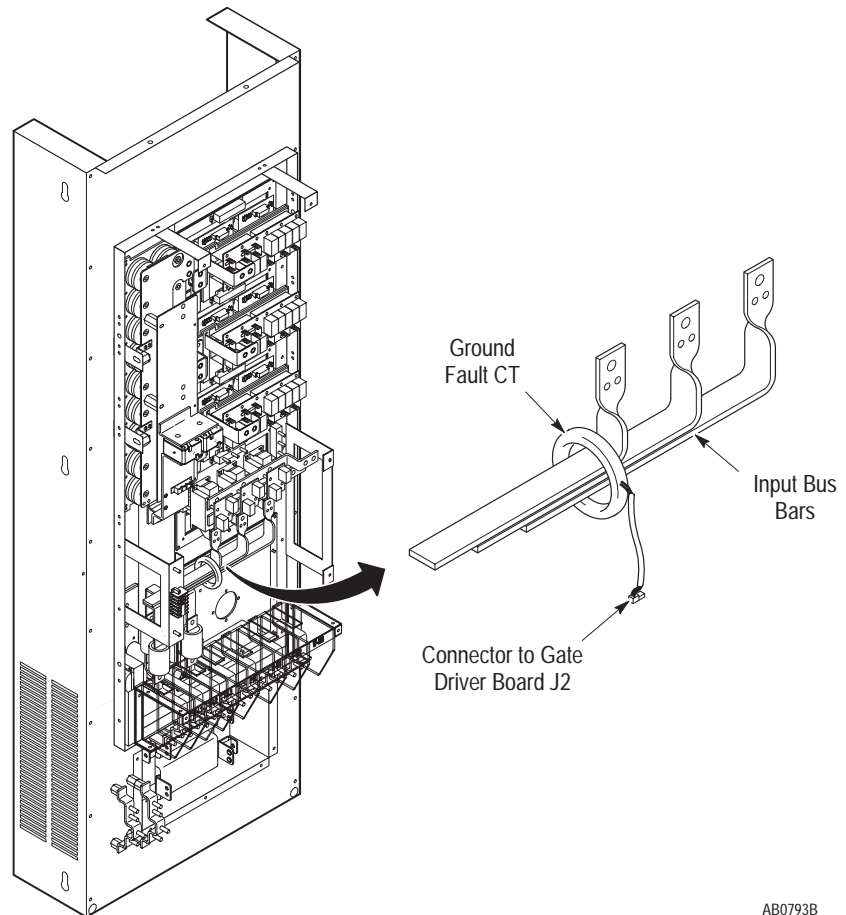


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Ground Fault CT

The Ground Fault CT encircles the Input Bus Bars and is located between the Input Fuse Assembly and the Input Rectifier Assembly.

Figure 5.8 Ground Fault CT



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Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the screws fastening the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
5. Remove the six screws fastening the Input Rectifier wiring to the Input Bus Bars.
6. Remove the six bolts fastening the Input Bus Bars to the Input Rectifier Assembly and the Input Fuse Assembly.
7. Slide the Input Bus Bars to the right to remove the bus bars and the Ground Fault CT, which encircles the bus bars, from the drive.
8. Slide the Ground Fault CT off the bus bars.

Installation

Install the Ground Fault CT in reverse order of removal, inserting the Input Bus Bars through the center of the Ground Fault CT. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.



ATTENTION: A possible short-circuit hazard exists. Position the fuse-to-inductor wire with the shrink-wrapped end of the wire connected to the Bus Inductor. Failure to position the wire as illustrated may result in serious injury or equipment damage.

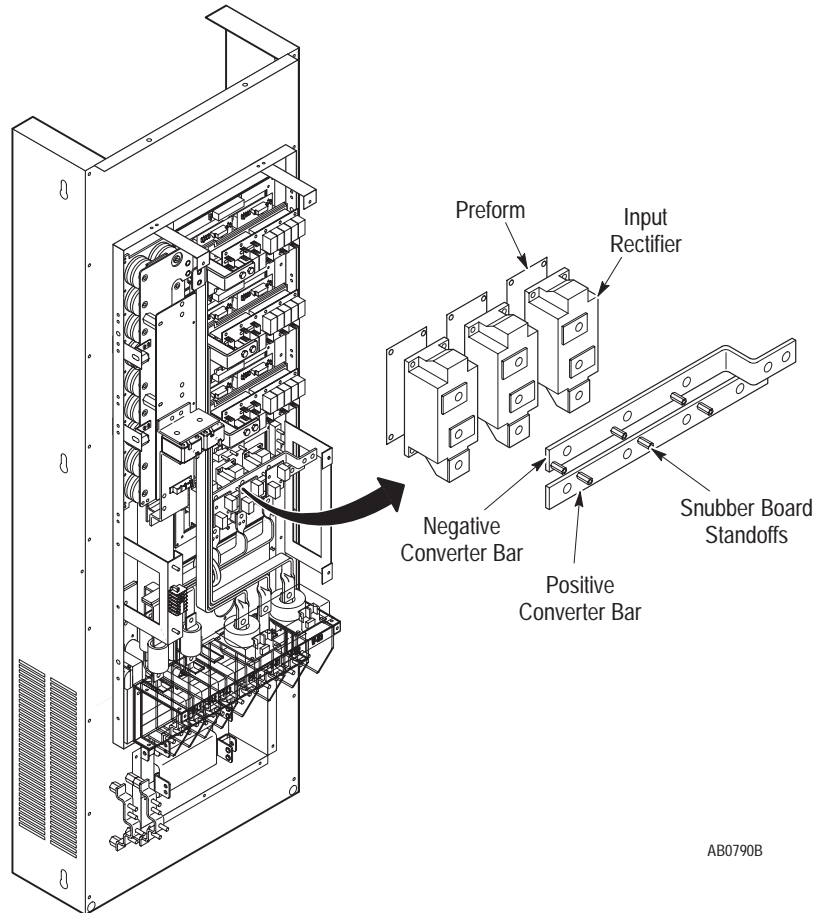


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Input Rectifiers

The Input Rectifiers are located toward the bottom of the heat sink.

Figure 5.9 Input Rectifiers



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Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
5. Remove the Input Rectifier Snubber Boards. Refer to Chapter 3 – Disassembly and Access Procedures, Removing an Input Rectifier Snubber Board.
6. Remove the three bolts fastening the Input Bus Bars to the Input Rectifiers.
7. Remove the six Allen-head screws fastening the positive and negative Converter Bus Bars to the Input Rectifiers.
8. Remove the Precharge Wiring Harness from the top of the rectifiers.
9. Remove the four screws fastening the Input Rectifier to the heat sink.
10. Pull the Input Rectifier away from the heat sink.

Installation

1. Clean all surfaces between the Input Rectifier and the heat sink using a soft, clean cloth.
2. Replace the Preform between the Input Rectifier and the heat sink.
3. Install the Input Rectifier in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

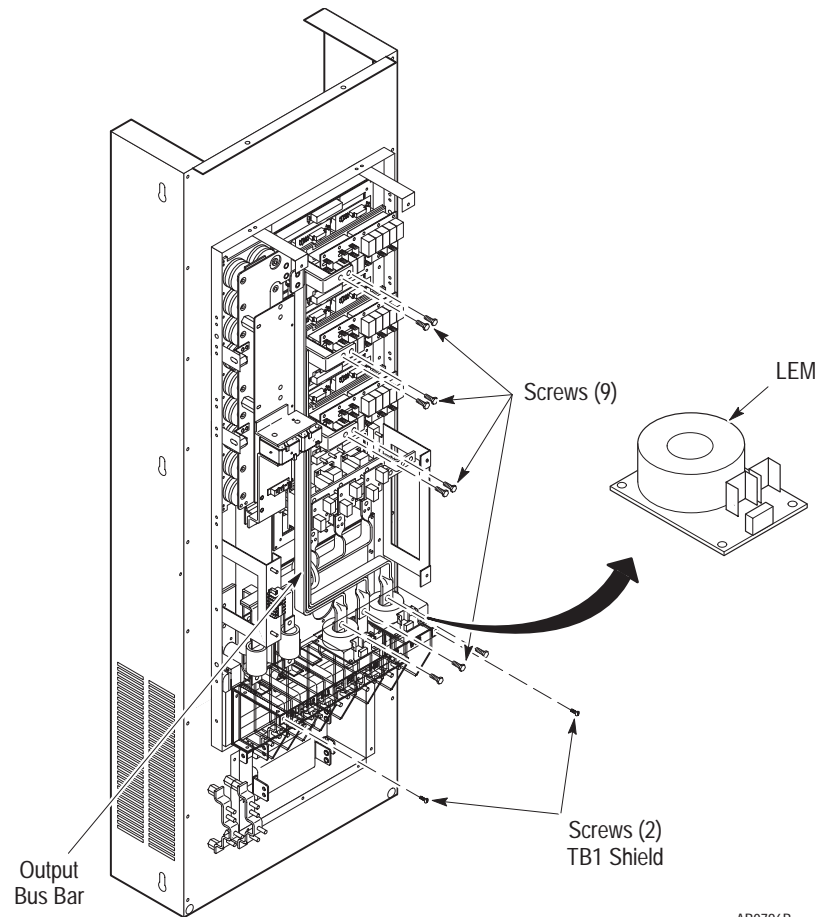


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

LEMs

The two LEMs are located above TB1 on the right side of the chassis.

Figure 5.10 LEMs



AB0796B

Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus to discharge any voltage. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
5. Remove the nine bolts fastening the Output Bus Bars to the Power Module Assembly and TB1.
6. Pull the Output Bus Bars out from the drive.
7. Remove the two screws fastening the TB1 shield to the TB1 Assembly.
8. Pull the TB1 shield away from the drive.
9. Remove the four screws fastening the LEM Interface Board to the standoffs.
10. Lift the LEM up and away from the drive.

Installation

Install the LEMs in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

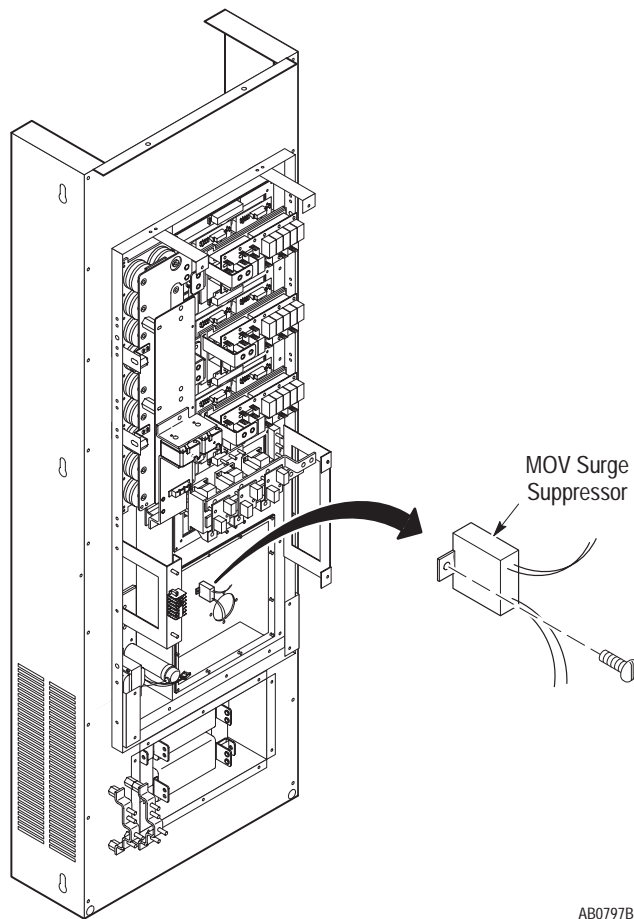


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

MOV Surge Suppressor

The MOV Surge Suppressor is located on top of the Fan Cover Plate. The MOV protects the drive from high voltage surges above approximately 1,000 volts. Replace it if it is burned, expanded, or ruptured after such events as a lightning strike, or inadvertent connection of the drive input to a voltage source substantially above nameplate voltage.

Figure 5.11 MOV Surge Suppressor



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
5. Remove the three screws fastening the MOV Surge Suppressor wires to the Input Bus Bars.
6. Remove the screw fastening the MOV Surge Suppressor wire to TB1 terminal PE.
7. Remove the screw fastening the MOV Surge Suppressor to the chassis.
8. Pull the MOV Surge Suppressor from the drive.

Installation

Install the MOV Surge Suppressor in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.

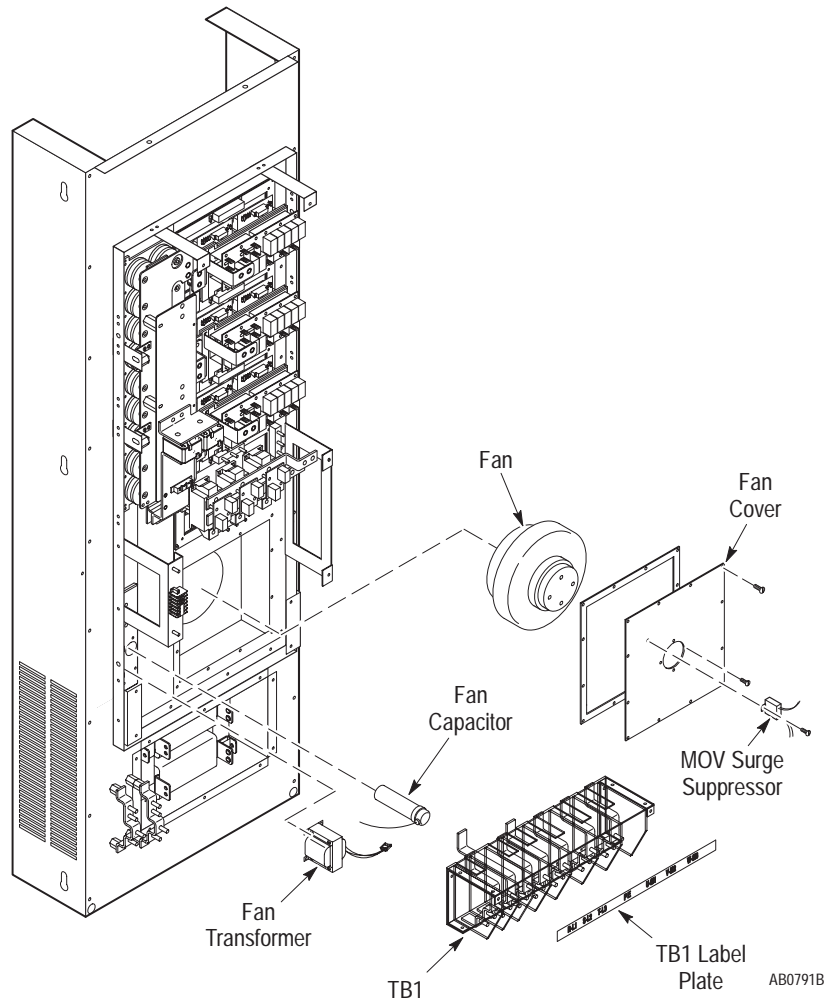


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

Fan and Transformer Assembly

The Fan is located in the chassis and under TB1 at the bottom of the heat sink. The Fan Transformer and Fan Capacitor are located in the bottom left corner of the chassis.

Figure 5.12 Fan and Transformer



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Hazard of electric shock exists. Up to 1,600 VDC will be on J1 if the Snubber Resistor is open. Measure for zero (0) VDC from Snubber Board terminal TP3 to plus (+) bus before removing connector J1. Use a resistor greater than 1 ohm and less than 100 ohm, rated for 25 watts minimum, between TP3 and plus (+) bus to discharge any voltage. Refer to Chapter 3 – Disassembly and Access Procedures, Removing a Power Module Snubber Board.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

Access the Main Chassis:

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Remove the High Voltage Guard from the drive. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the High Voltage Guard.
4. Remove the Circuit Board Platform. Refer to Chapter 3 – Disassembly and Access Procedures, Removing the Circuit Board Platform.
5. Remove the nine bolts fastening the Output Bus Bars to the Power Module Assembly and TB1.
6. Pull the Output Bus Bars away from the drive.
7. Remove the Input Fuses. Refer to the removal instructions for Input Fuses in this chapter.
8. Remove the three bolts fastening the Input Bus Bars to the Input Rectifier and remove the six screws on the Input Bus Bars.
9. Remove the Input Bus Bars, with the Ground Fault CT encircling the bars, from the drive.

10. Remove the MOV Surge Suppressor. Refer to the removal instructions for the MOV Surge Suppressor in this chapter.

Remove TB1:

1. Remove the nut located on the lowest stud on Terminal PE.
2. Remove the four screws fastening the TB1 Assembly to the drive.
3. Pull the complete TB1 Assembly, with the shield and LEMS attached, away from the drive.

Access the Fan:

1. Disconnect the Fan Wiring Harness.
2. Remove the screws fastening the Fan Cover to the chassis.
3. Pull the Fan Cover assembly away from the drive.
4. Remove the screws fastening the fan to the Fan Cover to remove the fan.
5. Disconnect the Fan Capacitor from the Fan Wiring Harness.
6. Unscrew the Fan Capacitor from the chassis by hand.
7. Disconnect the Fan Transformer from the Fan Wiring Harness.
8. Remove the screws fastening the Fan Transformer to the chassis.

Installation

Install the Fan Assembly in reverse order of removal, with the following exceptions:

- Thread the fan wiring connector through the hole in the Fan Cover.
- Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.
- Install the Fan Capacitor to the chassis with M8 split washer and hand tighten.
- Connect the Fan Transformer red wire to TB1 terminal S-L2 and the black wire to TB1 terminal R-L1.

Important: Install washers on TB1 terminals with the serrated side up.

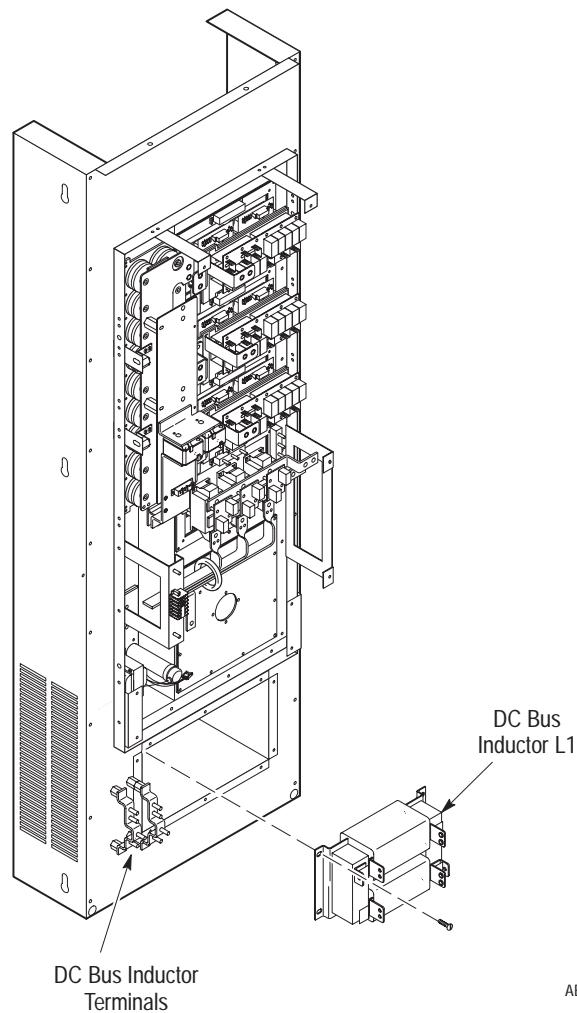


ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

DC Bus Inductor L1

DC Bus Inductor L1 is located at the bottom of the drive.

Figure 5.13 DC Bus Inductor L1



Removal



ATTENTION: Disconnect and lock out power from the drive before disassembling the drive. Failure to disconnect power may result in death or serious injury. Verify bus voltage by measuring the voltage between the +DC/-DC Brake Terminals. Do not attempt to service the drive until the bus voltage has discharged to zero volts.



ATTENTION: Wear a wrist-type grounding strap when servicing 1336 PLUS Drives. Failure to protect drive components against ESD may damage drive components. Refer to Electrostatic Discharge Precautions at the beginning of this chapter.

Important: Before you remove connections and wires from the drive components, mark the connections and wires to correspond with their component connections and terminals to prevent incorrect wiring during assembly.

1. Remove power from the drive.
2. Check for zero volts at the +DC/-DC Brake Terminals and for absence of control voltage.
3. Disconnect AC input and motor output wiring from TB1 to provide easy access to the DC Bus Inductor enclosure.



ATTENTION: The DC Bus Inductor weighs 100 lbs. Failure to use extreme caution in handling this part may result in serious injury.

4. Remove the eight bolts fastening the Bus Bar Cables to the DC Bus Inductor terminals.
5. Remove the four bolts fastening the DC Bus Inductor to the back panel of the chassis.
6. Remove the Bus Inductor from the drive.

Installation

Install DC Bus Inductor L1 in reverse order of removal. Refer to Chapter 3 – Disassembly and Access Procedures, Fastener Torque Specifications.



ATTENTION: If you mount the inductor remotely, verify the connections between the Bus Inductor, the Input Rectifier Bus Bars and the DC Brake Terminals. L1 of inductor should connect to the (+) Input Rectifier Bus Bar, L2 to the +DC Brake Terminal, L3 to the –DC Brake Terminal, and L4 to the (–) Input Rectifier Bus Bar. Refer to Chapter 4 – Component Test Procedures, Test 5 – Testing the Input Rectifiers.



ATTENTION: Replace all guards before applying power to the drive. Failure to replace guards may result in death or serious injury.

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Replacement Parts List

Chapter Objectives

This chapter illustrates and lists replacement parts for the 1336 PLUS Drives rated BP250 – BP450 or CP350 – CP450, and describes replacement parts ordering procedures.

The following illustration and table show you parts, part names, part numbers, locations, and chapters for replacement procedures.

Ordering Replacement Parts

For your convenience, the Rockwell Automation Drives Division and the Rockwell Automation Support Division provide efficient and convenient repair and exchange for eligible equipment.

A product service report number is required to return any equipment for repair. Your local Rockwell Automation distributor or area sales and support office can provide you with a product service report number.

You should return equipment to be repaired to the area sales and support center nearest you. Reference the product service report number on the carton and packing slip. Include:

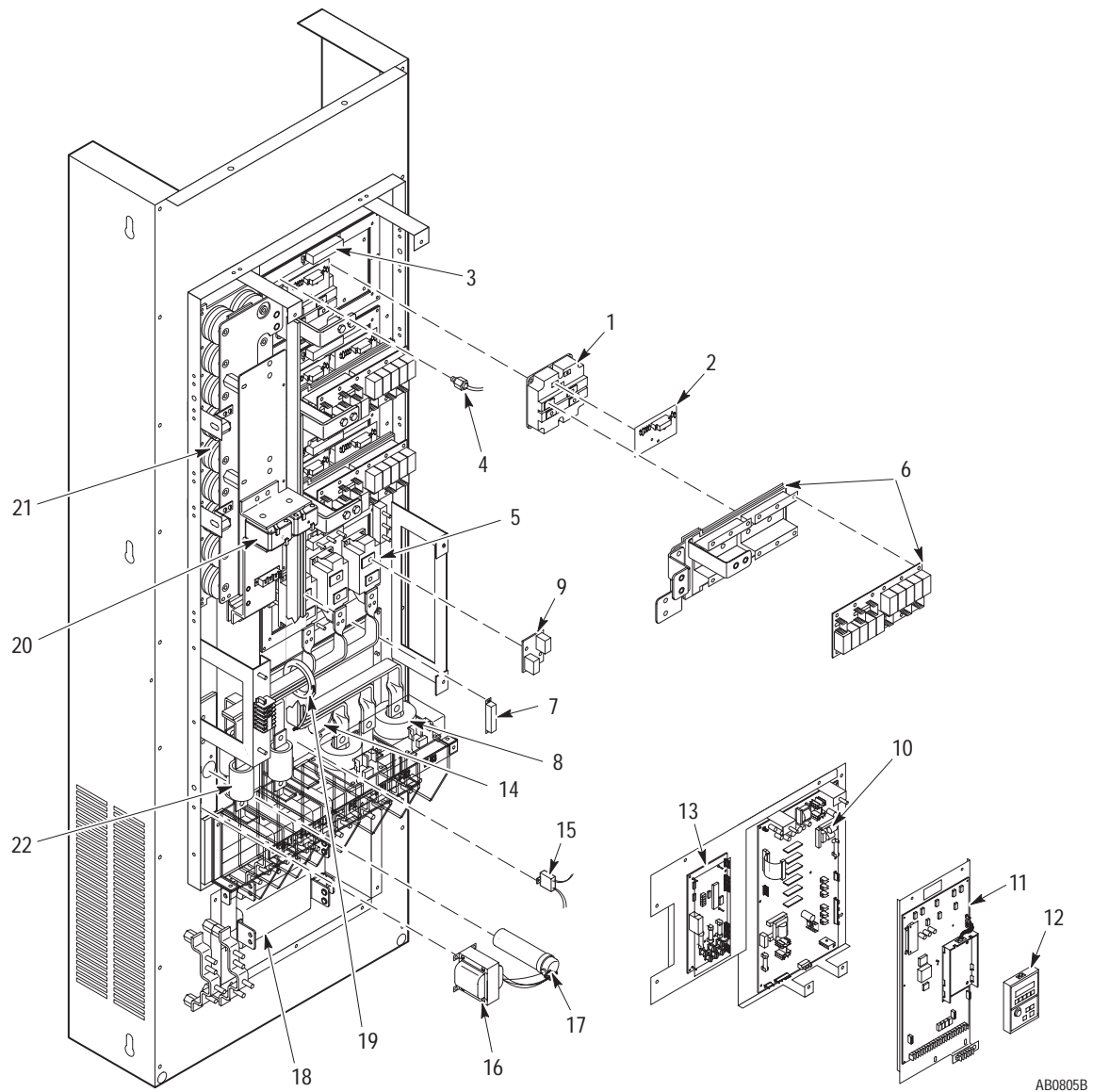
- Your company name
- Your company address
- The repair purchase order number
- A brief description of the problem

Contact your local Rockwell Automation distributor or sales office for a complete listing of area sales and support centers near you.

For parts catalog numbers, refer to the 1336 PLUS Spare Parts Pricing publication included with your drive documentation set.

Replacement Parts Listing

Figure 6.1 Parts for BP250 – BP450 Drives



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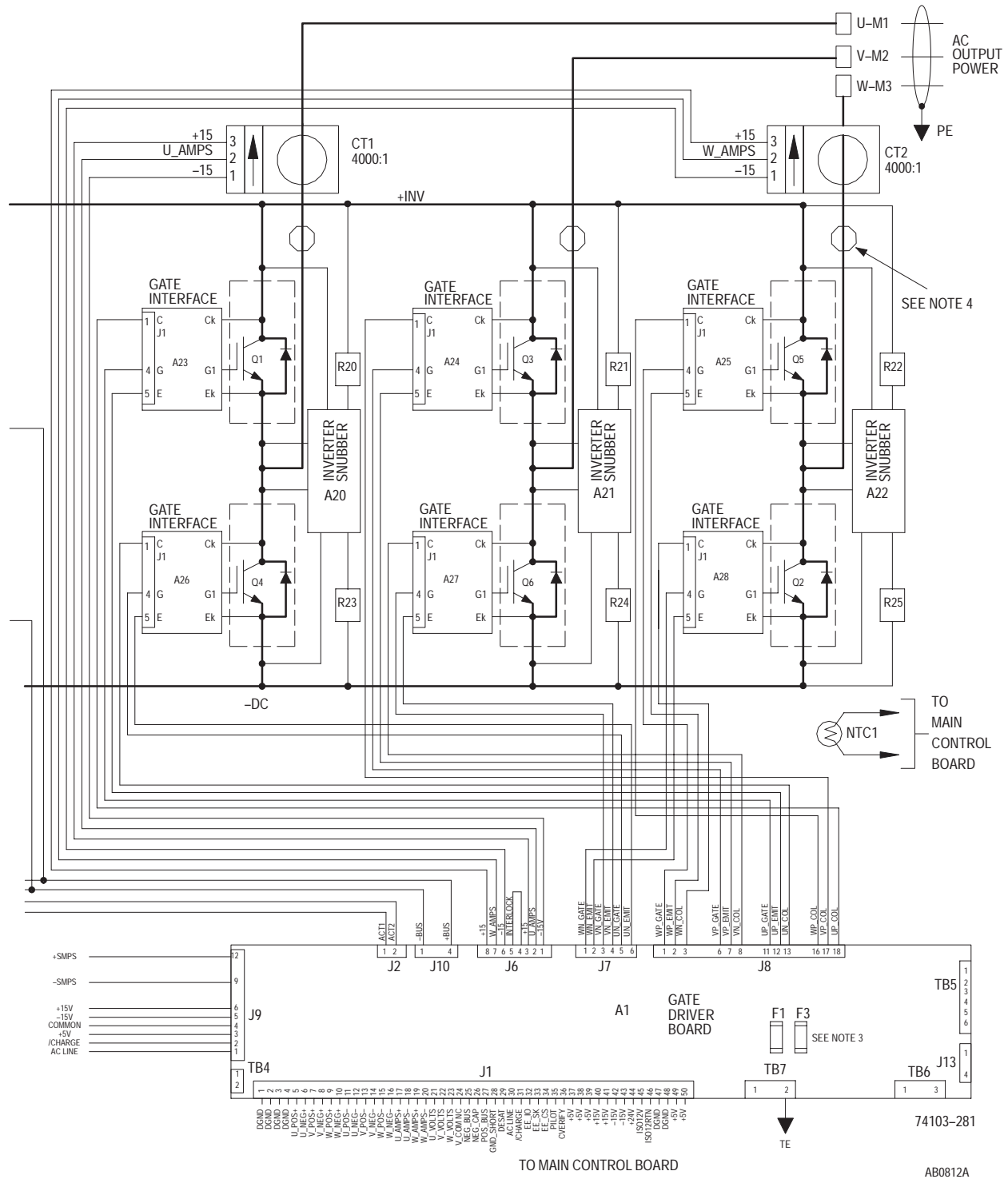
**Table 6.A Replacement Parts for BP250 – BP450,
CP350 – CP450 Drives**

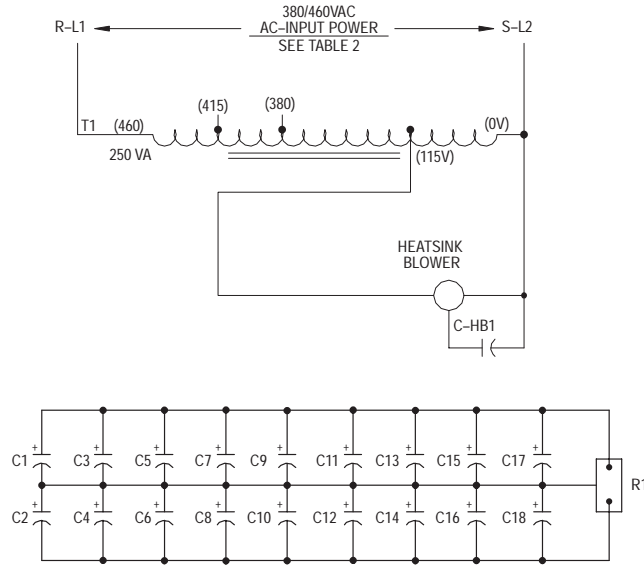
Callout	Symbol	Description	Location	Replacement Procedures
1	Q1 – Q6	Transistor (Power Module)	Heat Sink	Chapter 5, Power Modules
2	A23 – A28	Power Module Gate Interface Board	Power Module	Chapter 5, Power Modules
3	R20 – R22	Power Module Snubber Resistor	Heat Sink	Chapter 3, Removing a Power Module Snubber Board
4	NTC1	Thermistor	Heat Sink	Chapter 5, Thermistor
5	SCR1 – SCR3	Input Rectifier	Heat Sink	Chapter 5, Input Rectifiers
6	A20 – A22	Power Module Bus Bar and Snubber Board	Power Module	Chapter 3, Removing a Power Module Snubber Board
7	R1 – R3	Load-Sharing Resistor	Heat Sink	Chapter 5, Bus Capacitor Bank
8	CT1, CT2	LEM	TB1	Chapter 5, LEMs
9	A11 – A13	Input Rectifier Snubber Board	Input Rectifier	Chapter 3, Removing the Input Rectifier Snubber Board
10	A1	Gate Driver Board	Circuit Board Platform	Chapter 3, Removing the Gate Driver Board from the Mounting Plate
11	MAIN CONTROL BOARD	Main Control Board	Main Control Board Mounting Plate	Chapter 3, Removing the Main Control Board from the Mounting Plate
12	HIM	Human Interface Module	Enclosure Cover	Chapter 1, Module Removal
13	A10	Precharge Board	Circuit Board Platform	Chapter 3, Removing the Precharge Board from the Mounting Plate
14	FAN	Fan	Main Chassis	Chapter 5, Fan and Transformer
15	MOV1	MOV Surge Suppressor	Fan Cover Plate	Chapter 5, MOV Surge Suppressor
16	T1	Fan Transformer	Main Chassis	Chapter 5, Fan and Transformer
17	C-HB1	Fan Capacitor	Main Chassis	Chapter 5, Fan and Transformer
18	L1	DC Bus Inductor	Main Chassis	Chapter 5, DC Bus Inductor L1
19	CT3	Ground Sense CT	Input Bus Bar	Chapter 5, Ground Sense CT
20	F1	Bus Fuses/Diode Assembly	Capacitor Bus Bank	Chapter 5, Bus Fuses F1
21	C1 – C10	Bus Capacitors	Main Chassis	Chapter 5, Bus Capacitor Bank
22	CF1 – CF3	Input Fuses	Input Bus Bars	Chapter 5, Input Fuses

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**Schematics — BP250 – BP450 and
CP350 – CP450
250 – 450 HP 1336 PLUS Drives**







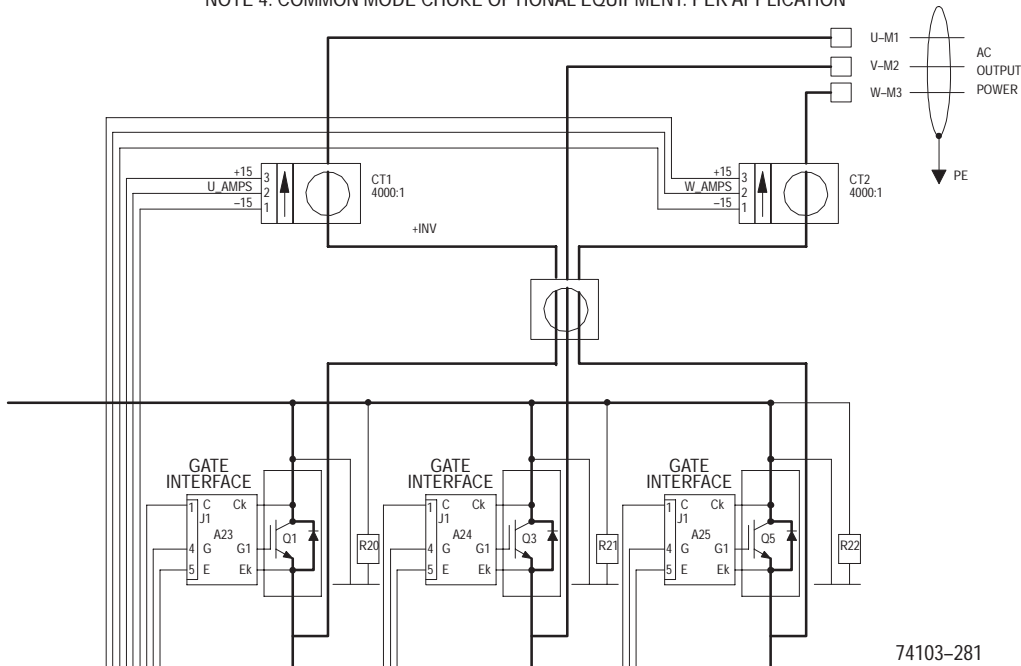
DETAIL 1 – 380/460 VAC

NOTES: – DETAIL 1:
1. C1 THRU C18 ARE 400 VDC CAPACITORS.

DETAIL 2 – 500/600 VAC

NOTES: – DETAIL 2:
1. C1 THRU C18 ARE 500 VDC CAPACITORS.

NOTE 4. COMMON MODE CHOKE OPTIONAL EQUIPMENT. PER APPLICATION



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Note 1: The Input Line Fuses for this product are supplied in the unit as follows:

380/460VAC FUSE CURRENT/TYPE				500V/600VAC FUSE CURRENT/TYPE			
HORSEPOWER	FUSE INFORMATION			HORSEPOWER	FUSE INFORMATION		
	RATING	TYPE	P/N		RATING	TYPE	P/N
250	450A	A70QS	25178-315-18	—	—	—	—
300	500A	A70QS	25178-315-19	—	—	—	—
350	600A	A70QS	25178-315-20	350	400A	A70QS	25178-315-18
400	600A	A70QS	25178-315-20	400	500A	A70QS	25178-315-19
450	700A	A70QS	25178-315-21	400	600A	A70QS	25178-315-20

Note 2: The Inverter Bus Fuse for this product is as follows:

HORSEPOWER	380/460VAC FUSE CURRENT/TYPE			500V/600VAC FUSE CURRENT/TYPE		
	FUSE INFORMATION			FUSE INFORMATION		
	RATING	CATALOG	P/N	RATING	CATALOG	P/N
ALL	2 x 450A	A65C450-4AB	25178-254-01	2 x 450A	A070URC33TT10450	188956-001

Note 3: The following is a listing of all printed circuit assemblies versus fuse and documentation information.

ITEM	B/M	SCHEMATIC DIAGRAM	FUSE INFORMATION			
			DESIGNATOR	RATING	TYPE	P/N
A1	74101-399-XX	74101-167	F1	1.0A/600V	CTK-R-1	25172-260-08
			F3	1.5A/600V	CTK-R-1.5	25172-260-09
A10	74101-181-51	74101-179	F1-F3	1.5A/600V	CTK-R-1.5	25172-260-09
A11-13	74103-867-51	74103-866	NONE			
A20-22	74103-784-51	74103-783	NONE			
A23-28	74103-845-51	74103-844	NONE			

Note 5: The Output Terminal Block (TB9) is only available on F Frame drives. This terminal block provides a three-phase, high voltage connection from the load side of the AC Input Line Fuses. Normally this connection is used to power an external control transformer (user supplied) or other auxiliary circuit. Refer to Figure 1.1 for location.

Important: Depending on the circuitry connected, additional fusing may be required.

Attention: The installation of auxiliary circuits must comply with the national codes and standards (NEC, VDE, BSA, etc.) and local codes regarding wire type, conductor size, branch circuit protection and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

The auxiliary circuit can be utilized to a maximum current capacity of 8 amperes RMS.

The maximum and minimum wire size accepted by TB9 is 4.0 and 0.8 mm (12 and 18 AWG). Use copper wire only with a minimum temperature rating of 75 °C. Maximum Torque is 0.90 – 1.81 N-m (8 – 16 lb-in.).

Terminal Blk TB9

	380/480V	500/600V
OUT1	480V	600V
OUT2	480V	600V
OUT3	480V	600V

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Glossary

AC Contactor: An alternating-current (AC) contactor is designed for the specific purpose of establishing or interrupting an AC Power circuit.

Adjustable Speed: The concept of varying the speed of a motor, either manually or automatically. The desired operating speed (set speed) is relatively constant regardless of load.

Adjustable Speed Drive (Electrical): The adjustable speed drive is comprised of the motor, drive controller and operator's controls (either manual or automatic).

Ambient Temperature: The temperature of the medium (air, water, earth) into which the heat of the equipment is dissipated.

Base Speed: The manufacturer's nameplate rating where the motor will develop rated power at rated load and voltage. With DC drives, it is commonly the point where full armature voltage is applied with full-rated field excitation. With AC systems, it is commonly the point where 60 Hz is applied to the induction motor.

BR: Refer to *Bridge Rectifier*.

Braking: A method of stopping or reducing the time required to stop an AC motor, and can be accomplished in several ways:

1. **DC-Injection braking (AC drives)** A method which produces electromagnetic braking forces in the motor by removing 2 AC motor (stator) phases and injecting DC current. The result is a linear braking characteristic (ramp) that does not diminish with motor speed. Application is normally limited to 10–20% of rated motor speed due to increased heating in the rotor.
2. **Dynamic braking (AC drives)** A method which produces electromagnetic braking forces in the motor by dissipating generated power into the DC bus through a resistive load. Braking force remains constant and is only limited by the thermal capacity of the resistors. The result is a linear braking characteristic (ramp) that does not diminish with motor speed.
3. **Regenerative braking** A method which produces electromagnetic braking forces in the motor by electronically controlling the return of generated power to the AC supply. The result is a controllable linear braking characteristic (ramp) that does not diminish with motor speed.

4. **Motor-mounted or separately-mounted brake** A positive-action, mechanical friction device. Normal configuration is such that when the power is removed, the brake is set. This can be used as a holding brake. (Note: A separately mounted brake is not one which is located on some part of the mechanical drive train other than the motor.)

Breakaway Torque: The torque required to start a machine from standstill. Breakaway torque is always greater than the torque needed to maintain motion.

Breakdown Torque: The breakdown torque of an AC motor is the maximum torque which it will develop with rated voltage applied at rated frequency.

Bridge Rectifier (Diode, SCR): A non-controlled, full-wave rectifier that produces a constant, rectified, DC voltage. An SCR bridge rectifier is a full-wave rectifier with a DC output that can be controlled by switching on the gate control element.

Bridge Rectifier: A full-wave rectifier that conducts current in only one direction of the input current. AC applied to the input results in approximate DC at the output.

British Thermal Unit (BTU): The quantity of heat required to raise one pound of water by one degree Fahrenheit.

BTU: Refer to *British Thermal Unit*.

Bus: A single path or multiple parallel paths for power or data signals to which several devices may be connected at the same time. A bus may have several sources of supply and/or several sources of demand.

Bus Sense: A signal transducer that generates a signal proportional to the current in the drive's DC bus. The control logic uses this signal to sense the presence or absence of bus voltage.

CEMF: Refer to *Counter Electromotive Force*.

CMOS: Complimentary Metallic Oxide Semiconductor. A semiconductor device in which an electric field controls the conductance of a channel under a metal electrode called a gate.

Cogging: A condition in which a motor does not rotate smoothly but steps or jerks from one position to another during shaft revolution. Cogging is most pronounced at low motor speeds and can cause objectionable vibrations in the driven machinery.

Constant Torque Range: A speed range in which a motor is capable of delivering a constant torque, subject to cooling limitations of the motor.

Constant Voltage Range: (AC Drives) The range of motor operation where the drive's output voltage is held constant as output frequency is varied. This speed range produces motor performance similar to a DC drive's constant horsepower range.

Constant Volts per Hertz (V/Hz): The V/Hz relationship exists in AC drives where the output voltage is directly proportional to frequency. This type of operation produces constant rated torque as the motor's speed varies.

Continuous Duty (CONT): A motor that can continue to operate without stopping and remain within the insulation temperature limits after it has reached normal operating (equilibrium) temperature.

Converter:

1. A device for changing AC to DC. This is accomplished through use of a diode rectifier or thyristor rectifier circuit.
2. A device for changing AC to DC to AC (e.g., adjustable frequency drive). A frequency converter, such as that found in an adjustable frequency drive, consists of a rectifier, a DC intermediate circuit, an inverter, and a control unit.

Counter Electromotive Force (CEMF): The product of a motor armature rotating in a magnetic field. This generating action takes place whenever a motor is rotating. Under stable motoring conditions the generated voltage (CEMF) is equal to the voltage supplied to the motor minus small losses. However, the polarity of the CEMF is opposite to that of the power being supplied to the armature.

Current Limiting: An electronic method of limiting the maximum current available to the motor. This is adjustable so that the motor's maximum current can be controlled. It can also be preset as a protective device to protect both the motor and the control from extended overloads.

DC Boost: Compensates for the voltage drop across the resistance of an AC motor circuit and the resulting reduction in torque.

DC Bus: A drive's power structure that transmits a rectified AC line power from the bridge rectifier to the output transistors.

DC Hold: Describes a "holding brake" function to stop motor rotation after a ramp-to-stop function is activated.

Diode: A solid-state uni-directional conductor.

Drift: A slow change in some characteristic of a device. For a drive, it is the deviation from the initial set speed with no load change over a specific time period. Normally the drive must be operated for a specified warm-up time at a specified ambient temperature before drift specifications apply. Drift is normally caused by random changes in operating characteristics of various control components.

Drive Controller (Variable Speed Drive) (Drive): An electronic device that can control the speed, torque, horsepower, and direction of an AC or DC motor.

1. **PWM drive** is a motor drive using pulse-width modulation techniques to control power to the motor. A high-efficiency drive used for high-response applications.
2. **SCR drive** is a motor drive that uses SCRs as the power control elements. Usually used for low-bandwidth high-power applications.
3. **Servo drive** is a motor drive that uses internal feedback loops for motor current and/or velocity.
4. **Vector drive** is an AC static motor drive using power-control techniques that produce motor performance similar to DC static drives.

Duty Cycle:

1. The ratio of working time to total time for an intermittently operating device. Usually expressed as a percentage.
2. The ratio of pulse width to the interval between like portions of successive pulses. Usually expressed as a percentage.

Dynamic Braking: Refer to *Braking*.

Efficiency: Ratio of output to input, indicated by a percentage. In a motor, it is the effectiveness with which the motor converts electrical energy into mechanical energy. In a power supply, it is the effectiveness with which the power supply converts AC power into DC power.

Electrostatic Discharge (ESD): A static-electricity discharge that may damage drive components. Refer to the ESD precautions found in this manual to guard against damage to drive components.

Enable: To activate logic by the removal of a suppression signal.

Enclosure: The housing in which equipment is mounted. They are available in designs for various environmental conditions. Refer to NEMA standard for specifications of different types of enclosures.

ENUM (Enumeration): An ANSI C standard extension to the C language. An ENUM is a set of named integer constants that specify all the legal values a variable of a given type may have. The keyword ENUM signals the start of an enumeration type.

ESD: Refer to *Electrostatic Discharge*.

Floating Ground: An electrical circuit common which is not at earth ground potential or the same ground potential as circuitry with which it interfaces. A voltage difference can exist between the floating ground and earth ground.

Force: The tendency to change the motion of an object with an exertion of energy from a separate source.

Full Load Torque: The full-load torque of a motor is the torque necessary to produce rated horsepower at full-load speed.

Gate:

1. A logic element that blocks or passes a signal, depending on the status of specified input signals.
2. The control element of an SCR.

GND Sense: A current transducer that detects an unequal or imbalanced current in the three-phase AC line or DC bus of the drive. The imbalance indicates an output ground fault condition.

Horsepower (hp): A unit of power: 1 hp = 33,000 ft-lb/min. = 746 watts.

IEC: International Electrotechnical Commission.

IGBT: Refer to *Insulated Gate Bipolar Transistor*.

Induction Motor: An induction motor is an alternating-current motor in which the primary winding on one member is connected to the power source. A secondary winding on the other member carries the induced current. There is no physical electrical connection to the secondary winding; its current is induced.

Inertia: A measure of a body's resistance to change in velocity, whether a body is at rest or moving at a constant velocity. The velocity can be either linear or rotational. The moment of inertia (WK^2) is the product of the weight (W) of an object and the square of the radius of gyration (K^2). The radius of gyration is a measure of how the mass of the object is distributed about the axis of rotation. WK^2 is usually expressed in units of lb-ft².

Insulated Gate Bipolar Transistor (IGBT): A type of transistor commonly used in drive-control devices.

Integral-Horsepower Motor: A motor that has a continuous rating of 1 hp or more, built into a frame.

International Organization for Standards (ISO): An organization established to promote development of international standards.

Interposing Relay: An interposing relay is a relay that accepts control signals of one logic level in order to provide isolated contact signals in a circuit operating at a different logic level.

Inverter:

1. An AC adjustable frequency drive.
2. A particular section of an AC drive. This section uses the DC voltage from a previous circuit stage (intermediate DC circuit) to produce a pulse-width-modulated or stepped AC current or voltage waveform that has characteristics similar to the desired sine-wave frequency.
3. A circuit whose output signal is the inverse of its input (a positive-going pulse is inverted to a negative-going pulse, and vice versa).

ISO: Refer to *International Organization for Standards*.

Isolation Transformer:

1. A transformer that provides DC isolation from other equipment not connected to that transformer secondary.
2. A transformer that provides noise isolation between the primary and secondary by such means as a Faraday shield.

Jogging:

1. In a numerical control system, an operator manually generating motion (continuously or incrementally) by closing a switch.
2. An operator generating motion by closing a switch.

Kinetic Energy: The energy of motion of a moving body.

LAD: Refer to *Linear Acceleration/Deceleration*.

LEM: A hall-effect current transducer that senses drive output current and generates a signal for the control logic.

Linear Acceleration/Deceleration (LAD): A circuit that controls the rate at which a motor is allowed to accelerate to a set speed or decelerate to zero speed. On most drives, this circuit is adjustable and can be set to accommodate a particular application.

Linearity: A measure of how closely a characteristic follows a straight-line function.

Locked-Rotor Current: Steady-state current taken from the line current with the a rotor at standstill (at rated voltage and frequency). This is the current when starting the motor and load.

Locked-Rotor Torque: The minimum torque that a motor will develop at rest for all angular positions of the rotor (with rated voltage applied at rated frequency).

Megger Test: A test used to measure an insulation system's resistance. This is usually measured in megohms by applying a high voltage.

MOV: Refer to *Surge Protection*.

National Electrical Code (NEC): A set of regulations governing the construction and installation of electrical wiring and apparatus, established by the National Fire Protection Association and suitable for mandatory application by governing bodies exercising legal jurisdiction. It is widely used by state and local authorities within the United States.

National Electrical Manufacturer's Association (NEMA): A non-profit organization organized and supported by electrical equipment and supply manufacturers. Some NEMA motor standards include horsepower (hp) ratings, speeds, frame sizes and dimensions, torques, and drive enclosures.

NEC: Refer to *National Electrical Code*.

Negative Slope: The location on a V/Hz curve where the break voltage exceeds the base voltage.

NEMA: Refer to *National Electrical Manufacturer's Association*.

Offset: The steady-state deviation of a controlled variable from a fixed setpoint.

Op Amp: An operational amplifier. A high-gain stable linear DC amplifier that is designed to be used with external circuit elements.

Open Loop System: A control system that has no means of comparing the output with the input for control purposes.

Overload Capacity: The ability of the drive to withstand currents beyond the system's continuous rating. It is normally specified as a percentage of full-load current endured for a specified time period. Overload capacity is defined by NEMA as 150% of rated full load current for one minute for "standard industrial DC motors."

PC:

1. Personal Computer.
2. Programmable Controller.
3. Printed Circuit.

Plugging: A type of motor braking provided by reversing either line voltage polarity or phase sequence so that the motor develops a counter torque that exerts a retarding force to brake the motor.

Pot: A potentiometer, or variable resistor.

Power: Work done per unit of time. Measured in horsepower (hp) or watts (W): 1 hp = 33,000 ft-lb/min. = 746 W.

Power Factor (Displacement): A measurement of the time phase difference between the fundamental voltage and fundamental current in an AC circuit. It represents the cosine of the phase angle difference.

$$F_p = \cos (\alpha - \beta)$$

Power Factor (Distortion): A measurement of the ratio of the real power (kW) to the apparent power (kVA). Distortion power factor takes into account harmonic voltage and current distortion as well as voltage-to-current displacement.

Preform: A flexible material used between an electronic component and the heat sink to which the component is attached. Preform provides maximum heat dissipation from the component to the heat sink.

Preset Speed: Describes one or more fixed speeds at which a drive operates.

Programmable Controller: A solid-state control system that has a user-programmable memory for storage of instructions to implement specific functions such as I/O control, logic, timing, counting, report generation, communication, arithmetic, and data file manipulation. A controller consists of a central processor, input/output interface, and memory. A controller is designed as an industrial control system.

Pull-In Torque: The maximum constant torque to which a synchronous motor accelerates into synchronism at rated voltage and frequency.

Pull-Out Torque: The maximum running torque of a synchronous motor.

Pull-Up Torque: The torque required to accelerate the load from standstill to full speed (where breakdown torque occurs), expressed in percent of running torque. It is the torque required not only to overcome friction, windage, and product loading but also to overcome the inertia of the machine. The torque required by a machine may not be constant after the machine has started to turn. This load type is characteristic of fans, centrifugal pumps, and certain machine tools.

PWM: Pulse-width Modulation. A technique used to eliminate or reduce unwanted harmonic frequencies when inverting DC voltage to sine wave AC.

Reactance: Pure inductance or capacitance, expressed in ohms, in a circuit. It is the component of impedance to alternating current that is not resistance.

Rectifier: A device that conducts current in only one direction, thereby transforming alternating current to direct current.

Regeneration: (AC drives) When the rotor synchronous frequency is greater than the applied frequency.

Regenerative Braking: Slows or stops a motor through regeneration. Refer to *Regeneration* and *Braking*.

Resolution: The smallest distinguishable increment into which a quantity can be divided (e.g., position or shaft speed). It is also the degree to which nearly equal values of a quantity can be discriminated. For rotary encoders, it is the number of unique electrically identified positions occurring in 360 degrees of input shaft rotation. For D/A or A/D conversion, may be expressed as the number of bits in the digital value that corresponds to a full-scale analog value.

SCR: Silicon Controlled Rectifier. A solid-state uni-directional latching switch.

Service Factor: When used on a motor nameplate, a number that indicates how much above the nameplate rating a motor can be loaded without causing serious degradation (i.e., a motor with 1.15 S-F can produce 15% greater torque than one with 1.0 S-F).

Set Speed: The desired operating speed.

Shock Load: The load seen by a clutch, brake, or motor in a system that transmits high peak loads. This type of load is present in crushers, separators, grinders, conveyors, winches, and cranes.

Slip: The difference between rotating magnetic field speed (synchronous speed) and rotor speed of AC induction motors. Usually expressed as a percentage of synchronous speed.

Slip Compensation: Monitors motor current and compensates for speed lost due to increased motor slip. The amount of slip is proportional to the motor load.

Speed Range: The speed minimum and maximum at which a motor must operate under constant or variable torque load conditions. A 50:1 speed range for a motor with top speed 1800 rpm means the motor must operate as low as 36 rpm and still remain within regulation specification. Controllers are capable of wider controllable speed ranges than motors because there is no thermal limitation, only electrical. Controllable speed range of a motor is limited by the ability to deliver 100% torque below base speed without additional cooling.

Speed Regulation: The numerical measure (percent) of how accurately the motor speed can be maintained. It is the percentage of change in speed between full load and no load. The ability of a drive to operate a motor at constant speed (under varying load), without “hunting” (alternately speeding up and slowing down). It is related to both the characteristics of the load being driven and electrical time constants in the drive regulator circuits.

Surge Protection: The process of absorbing and clipping voltage transients on an incoming AC power line or control circuit. Surge protectors include MOVs (Metal Oxide Varistors) and specially designed R-C networks.

Synchronous Speed: The speed of an AC induction motor’s rotating magnetic field. It is determined by the frequency applied to the stator and the number of magnetic poles present in each phase of the stator windings. Mathematically, it is expressed as: Sync Speed (rpm) = $120 \times \text{Applied Freq. (Hz)} / \text{Number of poles per phase}$.

Torque: A turning force applied to a shaft, tending to cause rotation. Torque is equal to the force applied, times the radius through which it acts. Torque is measured in pound-feet, ounce-inches, Newton-meters, or gram-centimeters.

Transducer: A device that converts one energy form to another (e.g., mechanical to electrical). When a transducer is actuated by signals from one system or medium, it can supply a related signal to the other system or medium.

Transient: A momentary power deviation in an electrical or mechanical system.

Transistor: An active solid-state semiconductor device.

Work: A force moving an object over a distance.
(work = force x distance)

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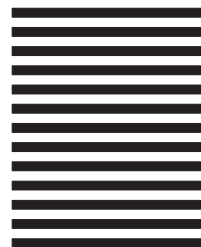
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